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Ubiquitous Computing -
Computing and Interaction in Context

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The talk includes work done at Lancaster University
and at TecO, University of Karlsruhe

Outline of the talk

- Vision & Motivation
- Physical interaction and Ubiquitous Computing
- Implicit interaction
- About prototyping, research methodology
- Evaluation in context

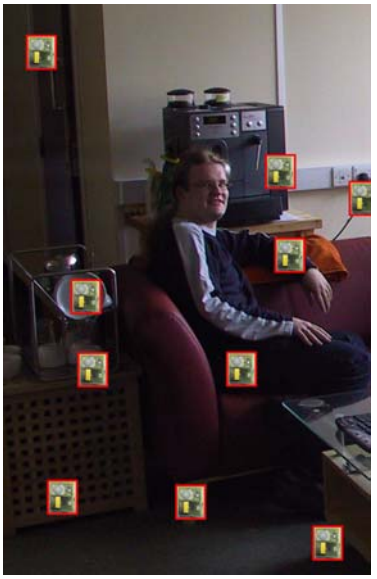
- Some recent projects

Vision of future environments



Vision of future environments





…two steps back

From text-based UIs to GUIs and direct manipulation

- Empowering non-expert users
- Teaching by demonstration
- Immediate feedback
- Actions are comprehensible and reversible
- New level of "explorability"

It was a major step, but it was (and still is) a learning process…

- many early GUIs were worse than command lines
- an interface is not good because it is graphical…
- or bad because it is command line…
- the interface has to be well designed and appropriate for the context of use

Facilitated the move towards widespread Personal Computing

- Considering the user as integral part of the system

Resulted in novel applications and new interfaces

The next step… Physical Interaction

Ubiquitous Computing – trying for the next step in interaction

- Considering also "what surrounds" computer and user as integral part of the system
  - Physical and social context: observable context, world knowledge, affordances, social values, …
- What is the next big step? How to get there?

Being-in-the-world

- Martin Heidegger, Philosopher (1889-1976)
- "the nature of human experience is based in engaged participation in the world"

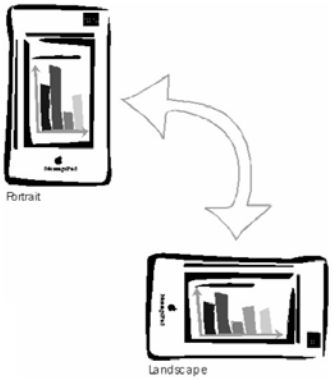
Physical → Experience

- More senses than vision and hearing
- Simple examples show how tempting it is
- But you have to have it physical – otherwise you can't create the experience

Our initial experience

- PDA example
- RFID work

Getting Physical
Initial experience (1998)



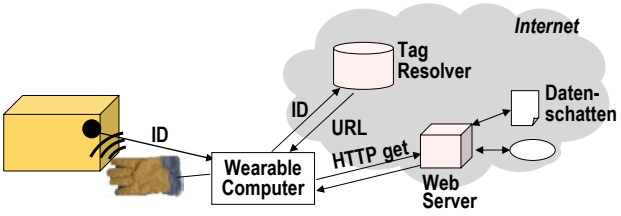
Context-Aware Computing
- location is just one dimension…

Extremely simple, but still it creates a new experience
- 2-Bit Input
- Not an input device
- Very specific function

Embedding Interaction
(CeBit2000 Demo)

Wearable Computing
- input by handling goods
- based on RFID
- integration with SAP System

"not using a computer – doing a job"
- not viewed as a computer
- … creates a new set of problems!



Ubiquitous Computing

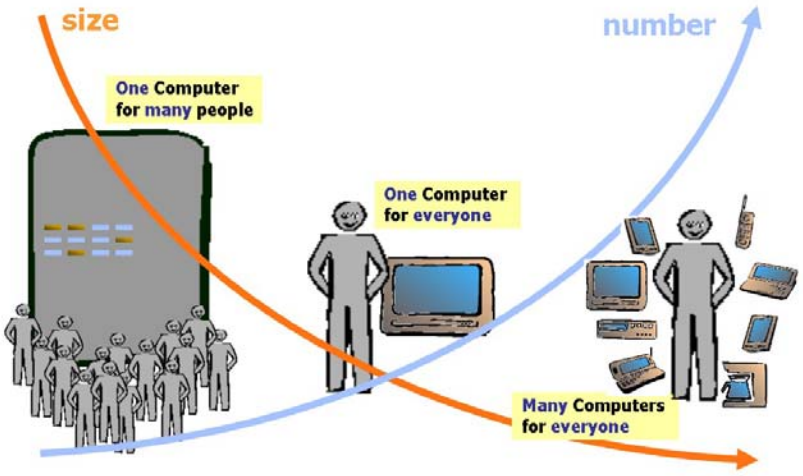
Influential Visions …

- Ubiquitous Computing (Mark Weiser, 1991)
- The Invisible Computer (Don Norman, 1998)
- Disappearing Computer (European IST, 2000)

Relate terms …

- Appliance Computing
- Pervasive Computing
- Situated Computing
- Ambient Intelligence
- Calm Computing
- Ambient Displays
- Context-Aware Computing
- …

Computers: Size + Number



Ubiquitous Computing starts to happen… and Interaction will be different

Some Vision Statements …

- ***"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."*** (Mark Weiser)
- *"Such a disappearance is a fundamental consequence not of technology, but of human psychology.* ***Whenever people learn something sufficiently well, they cease to be aware of it****. […] in this way are we freed to use them without thinking ..."* (Mark Weiser)
- *"… use the term "embodied virtuality" to refer to the process of drawing computers out of their electronic shells. The "virtuality" of* **computer-readable data** *[…]* ***is brought into the physical world****."* (Mark Weiser)
- *"[…] the primary motivation behind the information appliance is clear: simplicity.* ***Design the tool to fit the task so well that the tool becomes part of the task****, ..."* (Don Norman)

Beyond the Vision (1) … living rooms are different

Major research challenge – compatibility with everyday life

Context Acquisition in Everyday Environments

- Information about users, environments, and interaction

Including the Design Perspective (Human in the loop)

- Focus on foreground activity
- Interaction with accustomed physical environments
- Exploiting rich affordances of physical artefacts and structures that incorporate surfaces

Challenges

- Resolving the mismatch between traditional HCI and the vision of invisible computing
- Everyday environments are not controlled setting
- Unobtrusive and robust implementation

Beyond the Vision (2)
… living rooms are different

Observations

- Computing has moved beyond the desktop and becomes
  part of everyday environments
- Real world artefacts are augmented with computers
- No “computer users” anymore - user experience becomes a central concern (the challenge has moved beyond task efficiency)
- New interfaces and ways for interaction become feasible

Modes of Interaction

- No interaction with the system
- Transparent/invisible/implicit interaction
- Explicit interaction

Extending the Design Space for User Interfaces

	Explicit Interaction
Text UI	
GUI & direct manipulation	
Gestures & Speech	

Extending the Design Space for User Interfaces

	Explicit Interaction
Text UI	
GUI & direct manipulation	
Gestures & Speech	
Physical Interaction	

Extending the Design Space for User Interfaces

	Explicit Interaction	Implicit Interaction
Text UI		
GUI & direct manipulation		
Gestures & Speech		
Physical Interaction		

Implicit Interaction (1)

Implicit Human-Computer Interaction (iHCI)

- iHCI is the interaction of a human with the environment and with artefacts which is aimed to accomplish a goal. Within this process the system acquires *implicit inputs* from the user and may present *implicit output* to the user.

Implicit Input

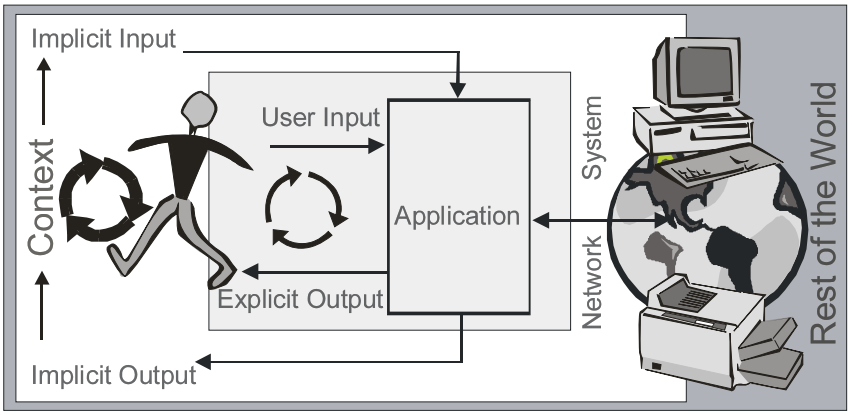
- Implicit input are actions and behaviour of humans, which are done to achieve a goal and are not primarily regarded as interaction with a computer, but captured, recognized and interpret by a computer system as input.

Implicit Output

- Output of a computer that is not directly related to an explicit input and which is seamlessly integrated with the environment and the task of the user.

Implicit Interaction (2)

Invisibility & transparent use vs. traditional explicit human computer interaction



How to interact with the Ubiquitous Computer?

Physical World becomes an integral part of the UI

- Everyday objects and spaces become the interfaces to otherwise invisible computing systems
- Interaction away from the desktop and as part of human activity in a physical world
- Experience is a central issue

Departure from Standard User Interfaces

- Non-traditional technologies: sensors, embedded systems, perceptual components, variety of output devices…
  → Every door handle may be an interface component.
- New interaction metaphors will emerge
- New models will be required (e.g. considering a door handle a widget may not be the best way of modelling the problem)

How to get there?

- Prototyping, exploring the possibilities…

Why Prototyping?

Hypothesis

Prototypes are essential to learn and understand and experience interaction in ubiquitous computing

From the idea to knowledge

- Prototyping has been central to hallmark research in the area (e.g. ParcTab, ActiveBadge)
- Learning occurs when along the prototyping process as well as in use

Towards a Methodology

- Analysing artefacts and how they are used
- Prototyping context-aware artefacts (recording issues in the process)
- "Confronting" **real** people with these enhanced artefacts (version 0.001)
- Deployment in a living lab environment
- Facilitating everyday environments with real users

Evaluation

- Prototypes can be the means for evaluation

Lessons Learned from Prototyping

About the process

- Valuable, allows new insight
- Chance inventions / side findings
- It is expensive and time consuming
- The wheel is reinvented and re-implemented over and over
- Need for building blocks and platform

About the prototypes

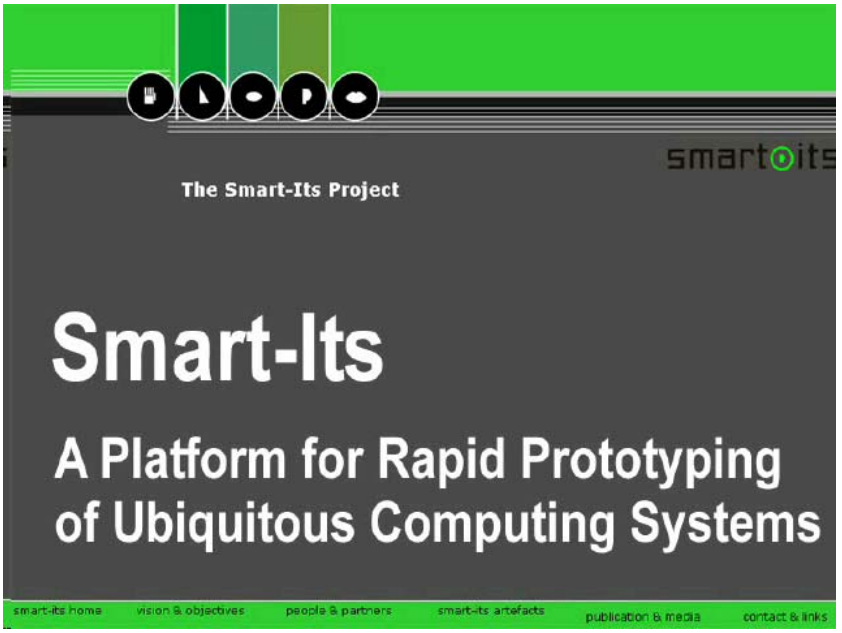
- Prototypes are similar for
  - processing
  - communication
  - Debugging I/O
- … but differ greatly in
  - Sensing
  - Actuators

Smart-Its –
A Computing Platform for Smart Objects

Means for exploring applications and new forms of physical interaction

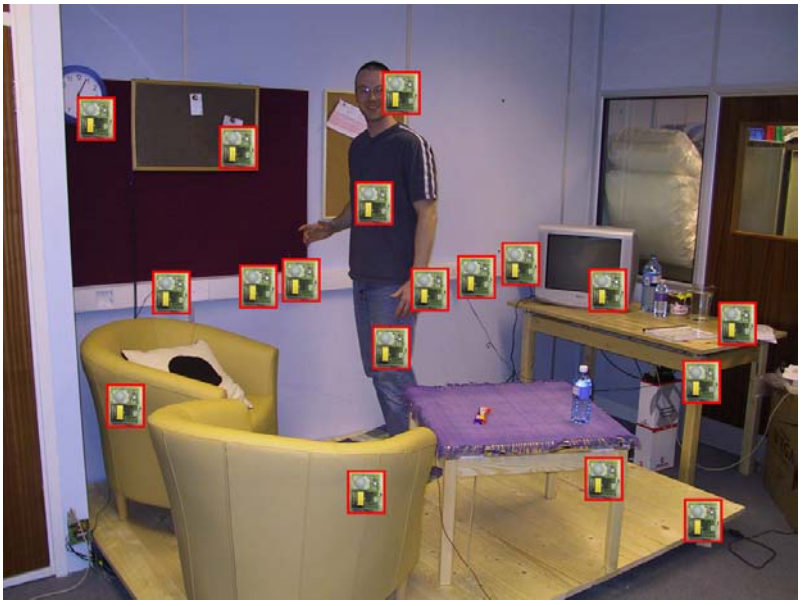
- Building scenarios
  - Rapid-prototyping of interactive and context-aware computing applications
  - Assessing the potential as an enabling technology for ubiquitous computing in various application domains
- Requirements
  - Need for input/output (connecting sensors and actuators)
  - Wireless communication
  - Price, size and power consumption matters now – even if the future brings it anyway!
  - Modularity
  - Ease of use
- Understanding and refining the requirements

Prototyping Exercise - Impressions



Prototyping in the lab

Prototyping in the lab



Evaluation of physical interfaces and new interaction methods

Evaluation = Assuring validity/quality of results

Evaluation Methods

- proof of concept (you can do it and its reproducible)
- User workshops and user feedback (formal and informal)
- Living lab and monitoring of usage
- Controlled studies

Difficulties

- Evaluation in context – in a real environment (no lab condition)
- Stability of prototypes
- Causality – many things are changed at once
- Goal is often beyond "being faster" but still relevant for productivity. What are we evaluating?
  - Pleasure?
  - Creativity & Inspiration?
  - Experience?

Summary - so far…

Issues discussed

- Physical Interaction as the next step
- Disappearing UIs and the notion of implicit Interaction
- Prototyping is a important way to go
- Smart-Its - towards a platform to make prototyping affordable
- Evaluation in context

Caveat

- Humans are intelligent! If you give them an everyday object – but it is a manipulator for the digital world, even if hidden – they will use it!

[Weiser,91]

- *"They [Ubiquitous Computing technologies] weave themselves into the fabric of everyday life until they are indistinguishable from it."*

To advance Ubiquitous Computing

- ***We have to weave technologies and interaction into the fabric of everyday life until they are indistinguishable from it.***

Selected Prototypes & Projects

- TEA – a context aware mobile phone
- Context-Call – sharing context before you call
- Load sensing
- Surfaces as interaction devices
- Augmented commerce
- Pin&Play – wall become networks
- Wearable sensor systems – Authentication
- The Pendle – a minimal wearable computer
- …

Project TEA

(European project, completed in 2000)

Technology for Enabling Awareness

Project goal

- building an add-on component that supplies awareness to a mobile device

Technology

- Sensors to provide location independent contexts (acceleration, light, sound, temperature)

Project TEA cont.

Applications

- user interface adapts to situations/context

- Implemented example applications
  - automated profile chang
  - context sharing

- Recognized contexts
  - hand
  - table
  - Suitcase
  - wardrobe
  - outside

Context Call

(Follow up on TEA)

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

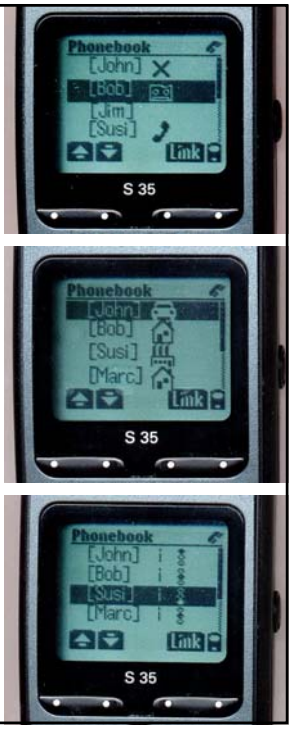
- **context matters - manly implicitly**
  - how important is it for me?
  - how convenient seams it for the other person?
  - relation between the communication partners?
  - what type of conversation will it be?
  - is it socially acceptable (topic/situation)?

- **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."

Context Call cont.

Implementation example – extended phone book

- **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



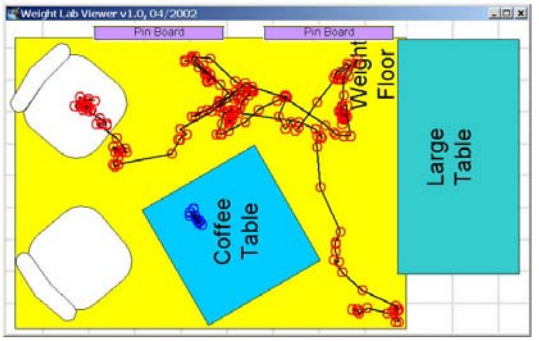
Load-Sensing Surfaces

Weight Lab

- Lab environment with load-sensing floor, tables, and shelves
- Common furniture, unobtrusively augmented (wireless)

Context Acquistion

- Tracking of people, objects, activities
- In presence of noise (cluttered surfaces)



Load-Sensing Surface

Surfaces as Interaction Device

Augmented Commerce

Retail learns from E-Commerce

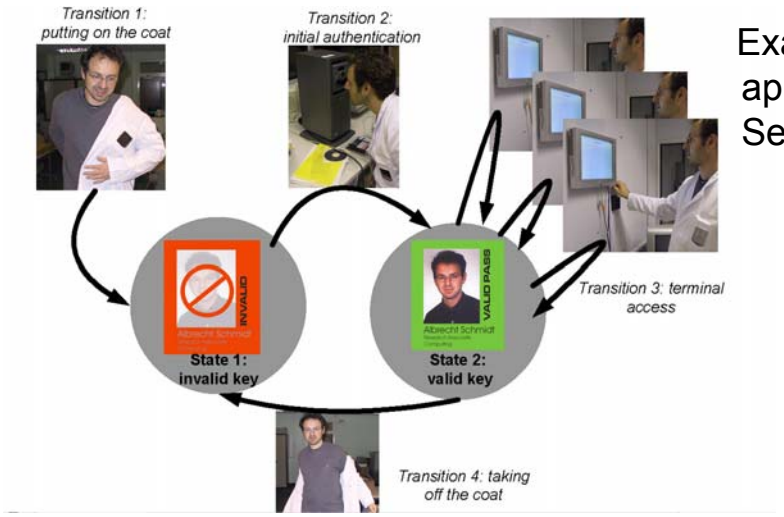
- Load sensing in shelf
- Detecting interaction, e.g.
  - Product selected
  - Putting things back in the shelf
- Physical recommender systems
  - Non personalized recommendations
  - Item related recommendations
  - Feedback

Situated Commerce vs. mobile Commerce

Pin&Play

- Enabling technology for interactive surfaces
- Communication (power bus protocol)
- Developing hardware & infrastructure & applications & user experience

Wearable Multi-sensor Systems (1)

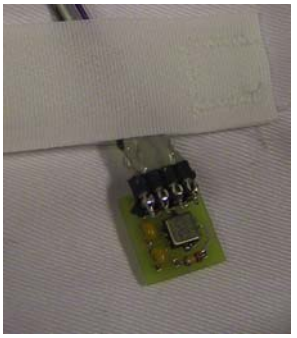


Example application Security

Wearable Multi-sensor Systems (2)

Prototype Implementation

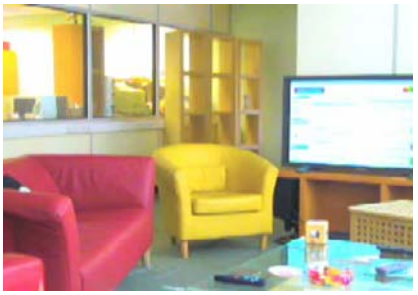
- acceleration sensors
- IPAQ PDA
- RFID reader



The *Pendle* –
a minimal wearable computer

A personalized, wireless, wearable device (Realized using Smart-Its)

- processor, memory, sensors, communication, battery
- customizing the local environment
- support for explicit and implicit interaction



Further Research Issues in Physical User interfaces

Platforms and Toolkits

- To enable “non-techies” to create physical UIs

New architectures for interactive systems

- Canonical set of building blocks: What is the equivalent of screen-based “GUI” objects in a physical world?
- Interface management: what is the equivalent of a windowing system in an interactive environment?

Evaluation methods and guidelines

- Finding a commonly accept approach
- Best practice guidelines

My general research interests

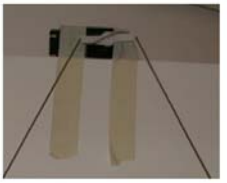
- Embedded interactive systems
- implicit interaction and context-aware systems
- novel interaction mechanisms & devices (mobile, tangible, physical)
- innovative media applications

Acknowledgements

- Work done at Lancaster together with Hans Gellersen, Kristof Van Learhoven, Martin Strohbach, Nicolas Villar
- Equator IRC, EPSRC (http://www.equator.ac.uk)
- Smart-Its Project (http://www.smart-its.org) Disappearing computer initiative of the European commission
- Pin&Play Project (http://ubicomp.lancs.ac.uk/pin&play/) funded by the European commission

Questions

key table as a sensor and a picture frame as actuator



Implementation

- Smart-Its sensor AddOn board
- Pressure sensor

Ambient Displays

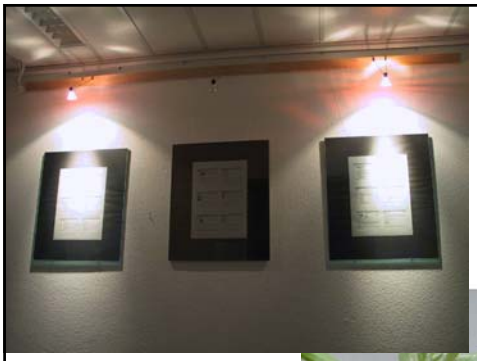
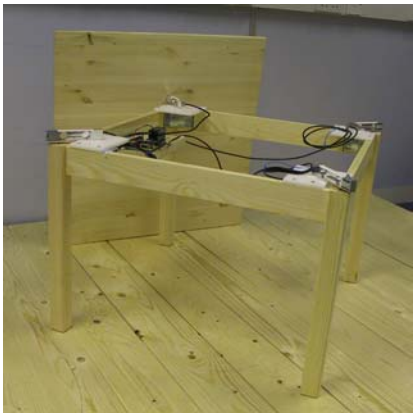
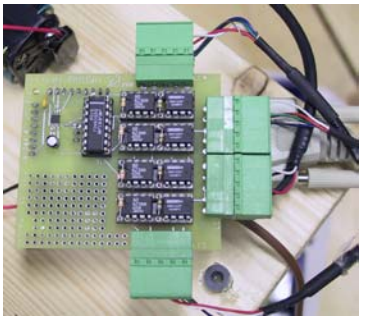
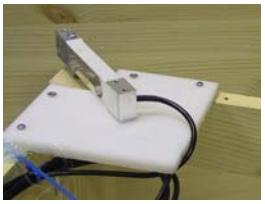


Table & Floor as Sensors





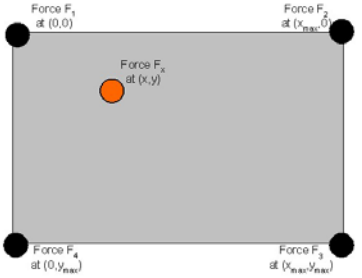
- Smart-Its sensor AddOn board
- 16 Bit DA
- Instrumentation Amps

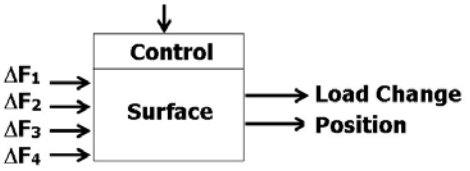


Load-Sensing Surfaces

Concept

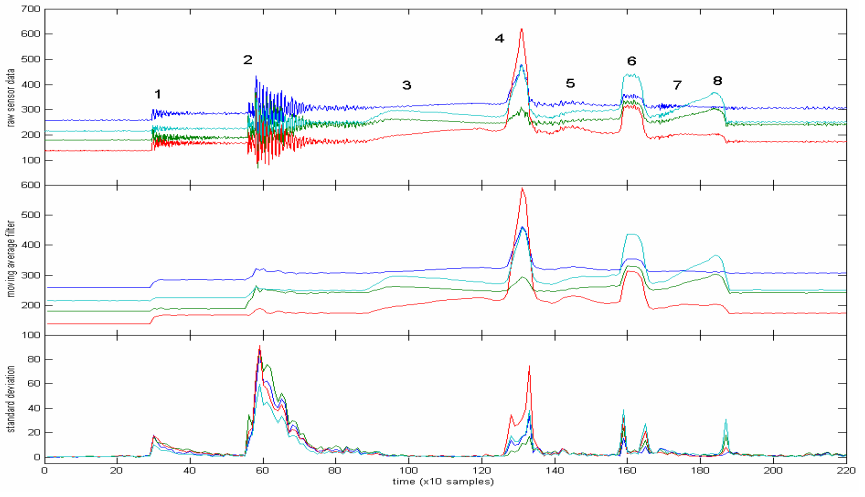
- Gravity is ubiquitous
- Surfaces: crossroads for human activity
- Pervasive load sensing
  - Not just weight
  - Position on surface
  - Object movement
  - Particular events
  - Traces





Load-Sensing Surface

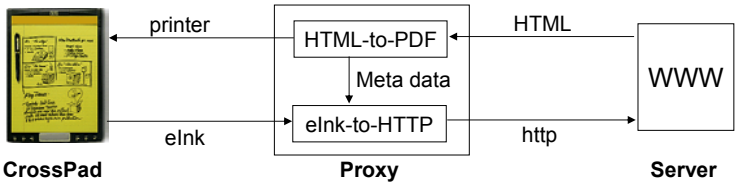
Surfaces as Interaction Device



Paper as input medium

Paper-to-Web

- **Using the CrossPad as Client for paper based input**
- **Transparent proxy between CrossPad and Web Server**
  - Conversion of web forms (HTML) into print documents
  - Recognition of handwriting in the paper forms and conversion



Application, Results

- Test in different domains (interviews, inventory)
- Usability: unobtrusive, transparent, custom interface (additional: paper copy)