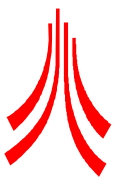
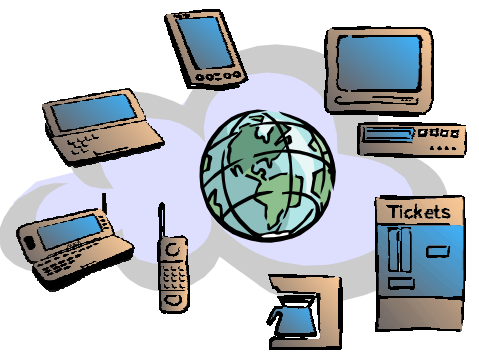
Computer-Augmented Environments: Back to the Real World

Hans-W. Gellersen



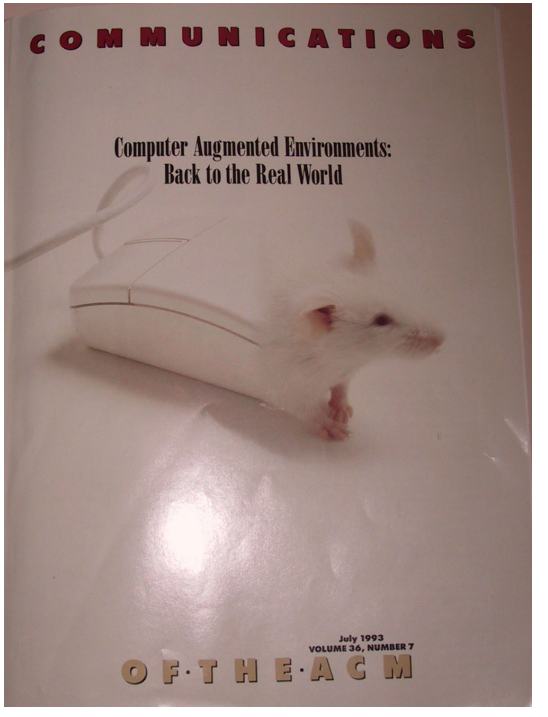
Lancaster University
Department of Computing
Ubiquitous Computing Research



What I thought this talk would be about

"Back to the Real World"

- Special Issue, CACM July 1993
- Workshop "Augmented Reality and Ubiquitous Computing", Feb 1993
- Early work on "physical integration" from interaction perspective
- Contrasting ubicomp and the AR model of augmented environments
  - ubicomp: the environment is the interface
  - AR: an overlaid interface registered with the environment



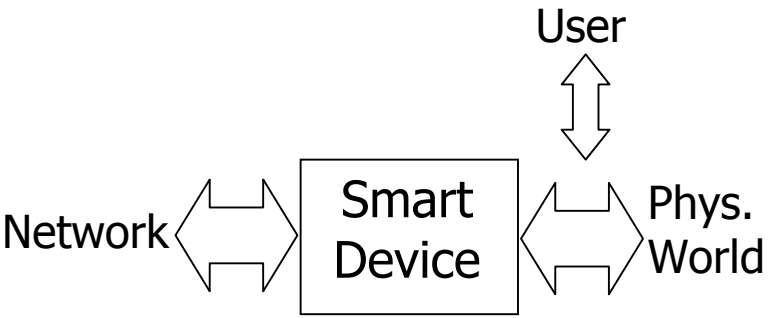
What this talk now will be about

- Motivating a design-driven perspective on ubicomp
- Some basic concepts and examples
  - Wellner's Digital Desk
- Interdisciplinary ubicomp research programmes
- Examples from work at Lancaster
  - Pin&Play
  - Load Sensing Surfaces
- Design Exercise in Groups

Motivating Scenario

Smart-Its

- Prototypical Smart Device
- Physical I/O
  - Sensors, Actuators
- Wireless networking
- Processing and memory
- Pervasive deployment
  - Attachment to existing things/structures
- No User Interface
  - The "host" thing/structure is the human interface



Technology research perspective I

"This is a distributed system"

- How to organize the network ?
  - Device discovery, dynamic configuration, etc
- What sort of communiction protocols ?
  - Communication model, abstractions etc.
- How to deal with scale ?
  - Number of nodes, spatial extent, density
- How to deal with resource limitations ?
  - Energy, processing
- How to support application development ?
  - Programming abstractions, middleware, e.g. service discovery

Technology research perspective II

"This is a sensor/control system"

- Sensing: which are the phenomena of interest ("context") ?
- What sensors to integrate for observation ?
- Sensor control, sensor fusion etc
- Perceptual computing: extracting meaning from sensor data
  - Transformations, architecture
- Communication models between sensor and observer
- Control: what variables to control in the environment ?
- Actuators, control interfaces, etc
- Control protocols
- Security
- etc.

Application research perspective

“this is an interesting application platform”

Design perspective I

"These are artefacts"

- Artefacts: invented things
  - as much product of innovation as our new technologies
- They have meaning/value in our lives
  - not strictly utilitarian; aesthetics, comfort, cultural, social etc
- Physical/Tangible Interaction
  - Physical affordances: suggesting and guiding action
  - Distributed interaction: actions across artefacts
- Spatial/ambient interaction
  - Interaction spread through space
  - Meaningful spatial relationships
  - Spatial organisation of action/communication
  - Ambient interaction: "spatial attention model"

Design perspective II

"These are computer-augmented artefacts"

- Combine unique capabilities of digital technology with properties of physical artefacts
- Computers as secondary artefacts ("in the background")
- Extend foreground capabilities of the primary artefacts
- Enable new relationships among artefacts
- Enable new interactions across artefacts
- **Preserve and exploit familiarity and physical affordance of the physical artefact**

What are affordances ?

My Cannon Cooker

- **Dual-fuel, dual-oven**

About affordances

Term comes from J.J. Gibson

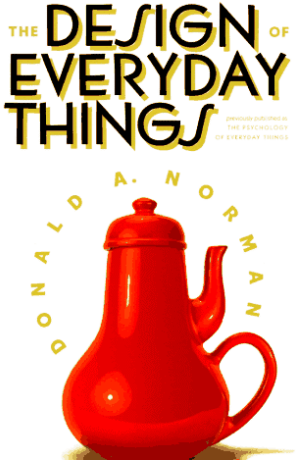
- "The ecological approach to visual perception", 1979
- Affordances as fundamental object of human perception
  - e.g. perceive stairs in terms of their "climbability"
  - refers to attributes of both object and actor

Developed for interaction design by Bill Gaver

- "Technology Affordances", Proceedings of CHI'91
  - Provision of affordances as design challenge

Popularized by Don Norman

- "The design of everyday things", 1988

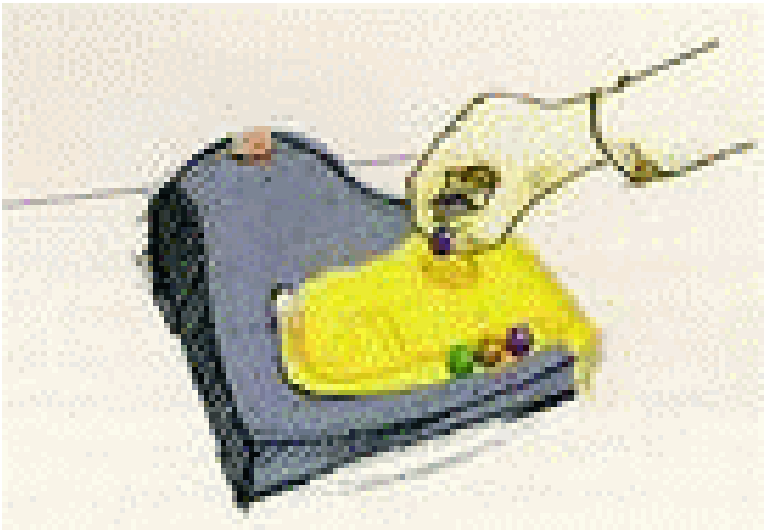


Examples of “hybrid designs”

- Bishop’s Marble Answering Machine
- Jeremijenko’s Live Wire
- Wellner’s Digital Desk

Bishop's Marble Answering Machine

- Physical interaction with digital information

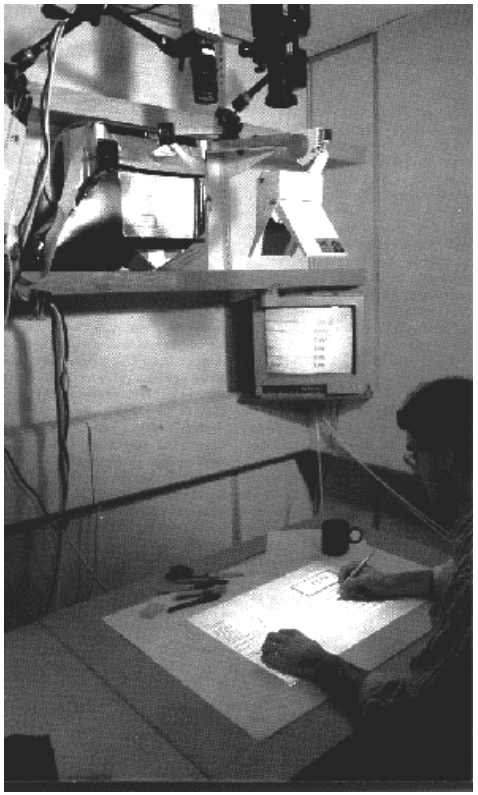


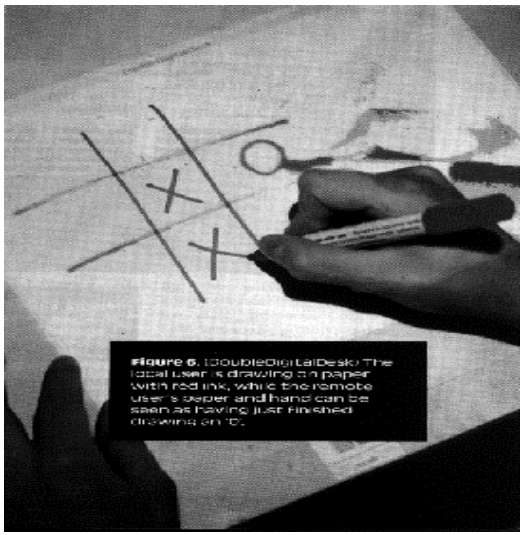
Examples: Jeremijenko's Live Wire

- Giving digital interaction a physical presence
- Ambient interaction

Examples: Wellner's Digital Desk

- interaction with paper and electronic documents
- Seamless transitions: physical and digital interaction





Interdisciplinary Ubicomp Research

The Disappearing Computer

- www.disappearing-computer.net
- EC Research Programme, started Jan. 2001
- 17 Projects, each multi-site, multi-national, multi-disciplinary
- Cross-project activities: research ateliers etc.
- Bringing together
  - Technology research
  - Design (Architecture, Products, Interaction Design)
  - Social Computing

The Disappearing Computer

The Programme Vision

"the computer disappears … new artefacts appear" …

"… as a consequence human-centered notions, such as real objects and everyday settings can come to the foreground"

Objectives

- Enabling smart artefacts as future versions of today's artefacts
- Architectures supporting new relationships and emergent functionality across many artefacts
- Understanding and designing user experience

The Disappearing Computer

Technology concerns

- Physical integration, software architecture, etc

Design research

- Incorporating context
- Managing attention
- Physical space, form and affordance
- New interactive styles

Social computing

- Incorporating sociological understandings
  - How people interact; the role of artefacts and places
- "From Human Factors to Human Actors"
- Enhancing social interactions

The Disappearing Computer

DC Jamboree

- Annual Project Review Meeting
- Exhibition / demonstrations of all projects
- Co-located with the Ubicomp 2002 Conference
- Gothenburg, Sweden, 30 Sept – 1 Oct

More Interdisciplinary Research

The Equator Programme

- www.equator.co.uk
- UK "Interdisciplinary Research Challenge", started late 2000
- "Technological Innovation in Physical and Digital Life"
- 8 Research Institutes across the UK
- Designers, Sociologists, Psychologists, Performance Arts, Software and Hardware Technology
  - Sociological field studies and cultural probes
  - Building technology and studying in practice

DC/Equator Work at Lancaster

- Smart-Its
- Pin&Play
- Load Sensing Surfaces

Pin&Play

Concept

- "The wall as network bus for the things attached"
- A new type of network to connect everyday objects on common surfaces such as boards and walls
- Use of familiar mechanism: "pinning objects to the wall" → "pinning nodes to the network"

Pin&Play

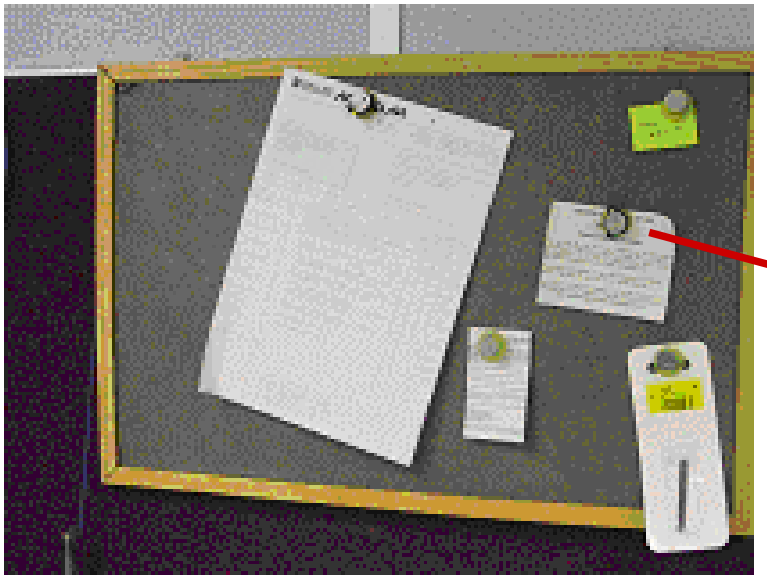
Components

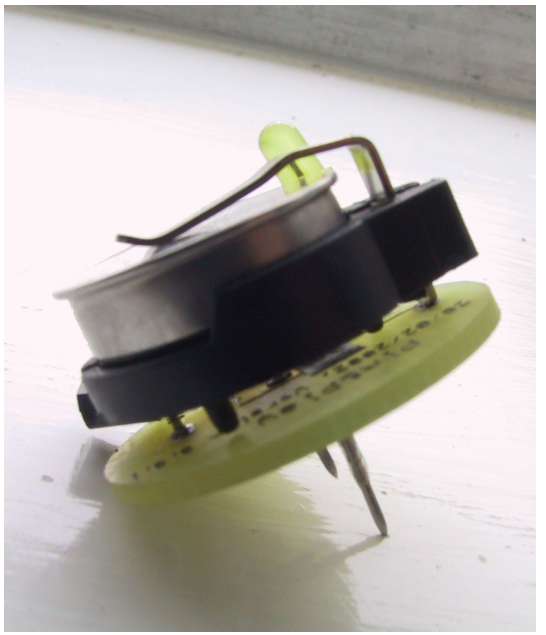
- Surface: Common surface augmented with conductive material to create network medium
- Connectors: pushpin-like physical connector for socket-less attachment of objects to the network
- Objects: any type of device/object with embedded computing and connector-interface
- Network: ad hoc behaviour: “Pin&Play”

Pin&Play

A Pin&Play Noticeboard

- Fully functioning prototype for proof of concept

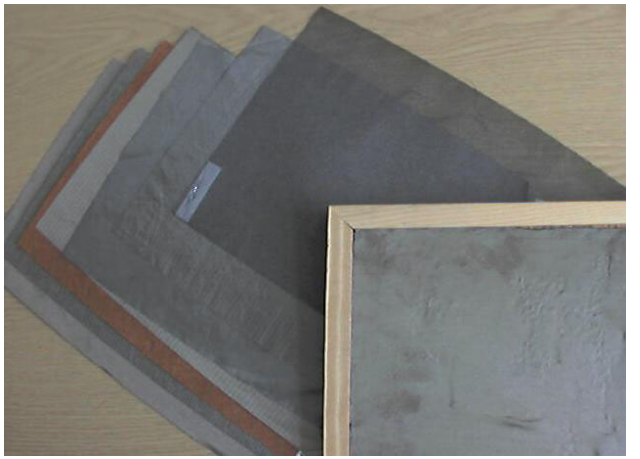




Pin&Play Noticeboard

Pin&Play Surface

- Corkboard augmented with two conductive sheets
- Ground layer on top, data/power layer hidden, cork as insulator
- Low cost, off-the-shelf, deployable at large-scale



Pin&Play Connectors

- Simple connector board with pushpin for two separate connection points

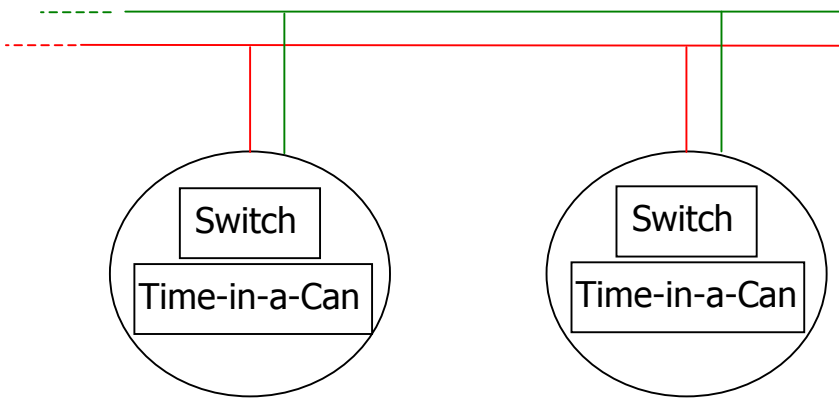
Pin&Play Noticeboard

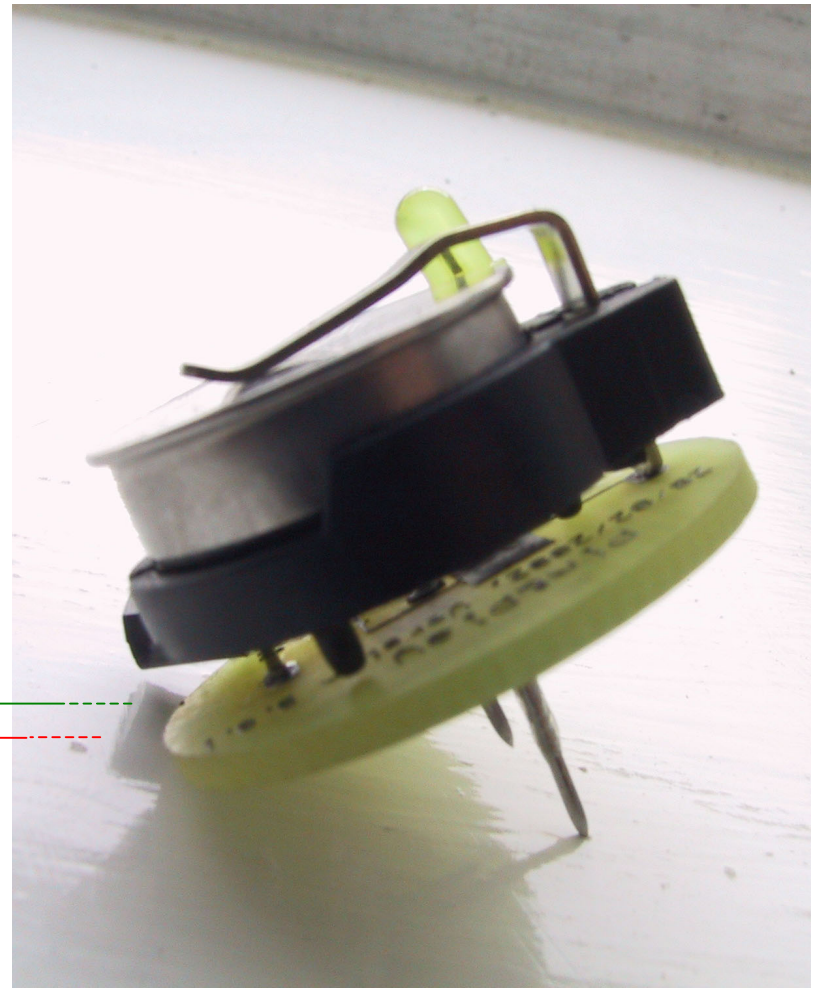
Pin&Play Objects

- 1-wire bus, Dallas MicroLAN
- 16300 bits/s

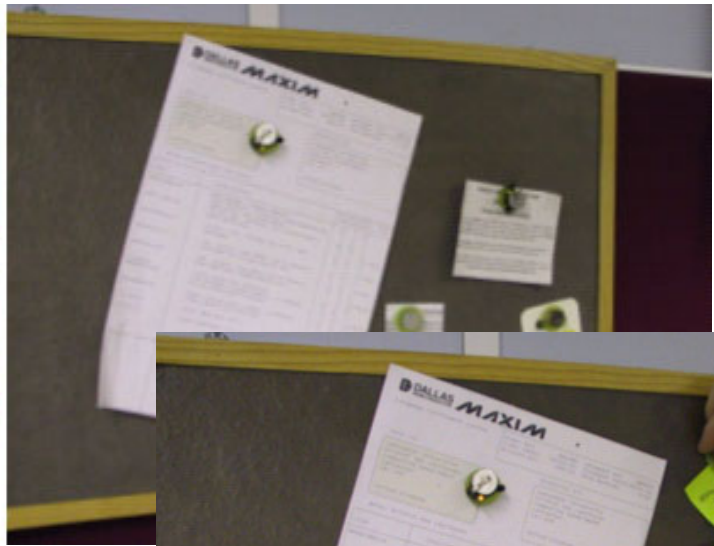
Pin&Play Objects

- "Smart Notification Pin": iButton and switchable LED
- Time-in-a-can iButton: memory, internal calendar and clock





Pin&Play Pinboard Scenario



User interaction

- insert or remove pin
- network detects change
- protocol to determine pin with highest priority

Network control

- External laptop connected as 1-wire network node
- runs network controller
- used to pre-set pins with priority and deadlines

Pin&Play

Technology Research

- Network surface development
- Simple and robust protocol design, zero maintenance
- Scalability and density (initial target: 25 nodes/sqm)

Application Research

- Augmented noticeboards and other interactive surfaces
- Embedded home control buses
  - Networking and free placement of controls (light switches, appliance controls etc.)
- Communication bus for wall-attached artefacts
  - Clocks, calendars, sensors, digital picture frames, …

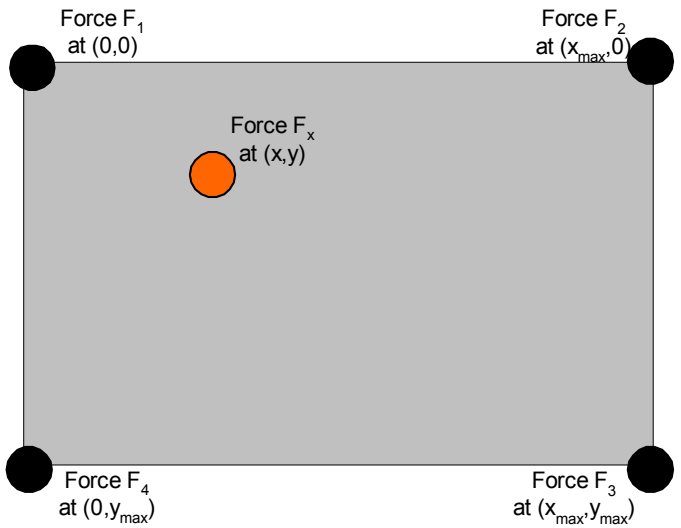
Load-Sensing Surfaces

Concept

- No physical thing can escape gravitation
- Use load-sensing as interface between the physical and the virtual
- Augment common surfaces (floor, tables, shelves): this is where gravitation pulls objects to

Principle

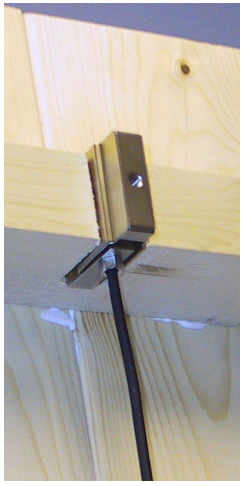
- Augment surface at the corners
- Force applied (e.g. by weight of an object, or explicit pressure) is detected as load depending on position of the pressure point
- i.e. surface detects weight/pressure and position



Load-Sensing Surfaces

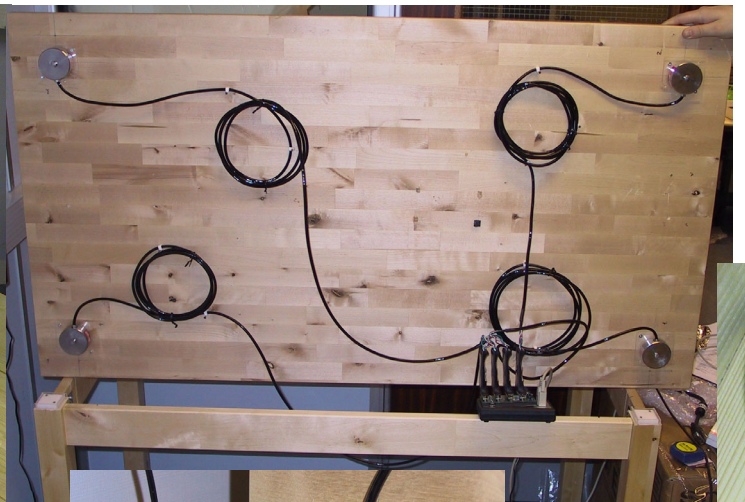
"Weight Lab"

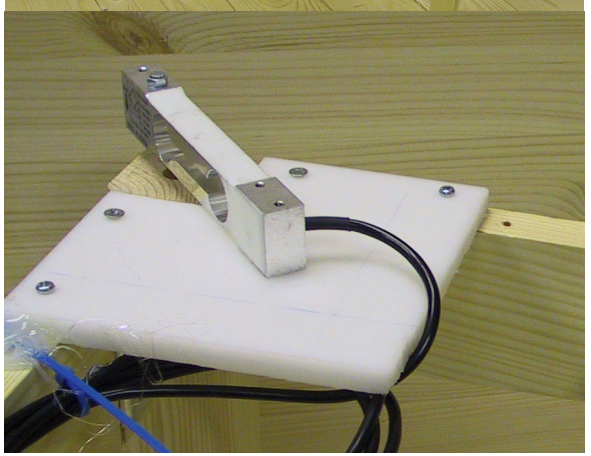
- Various augmented surfaces
- Floor: 240 x 180cm, up to 800kg load
- Larger table: up to 200kg
- Coffee table: up to 8kg, highly sensitive
- Shelves and trays

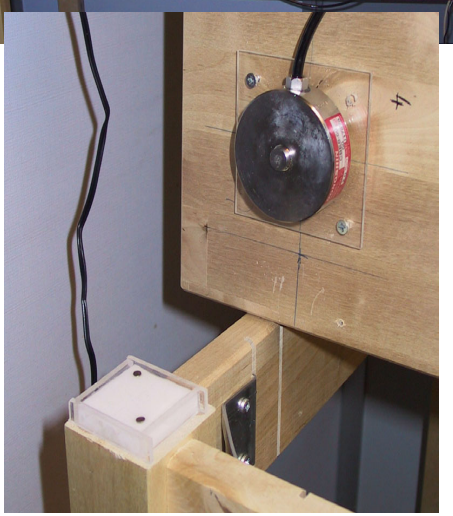


Floor with embedded S-load cell

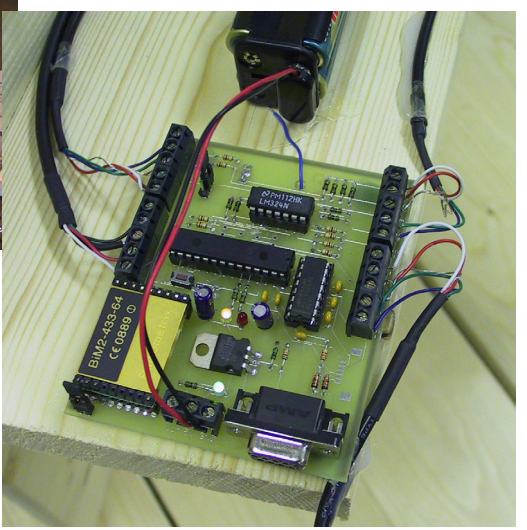
Load-Sensing Surfaces







Augmented tables



Sensor board with wireless communication

Load-Sensing Surface

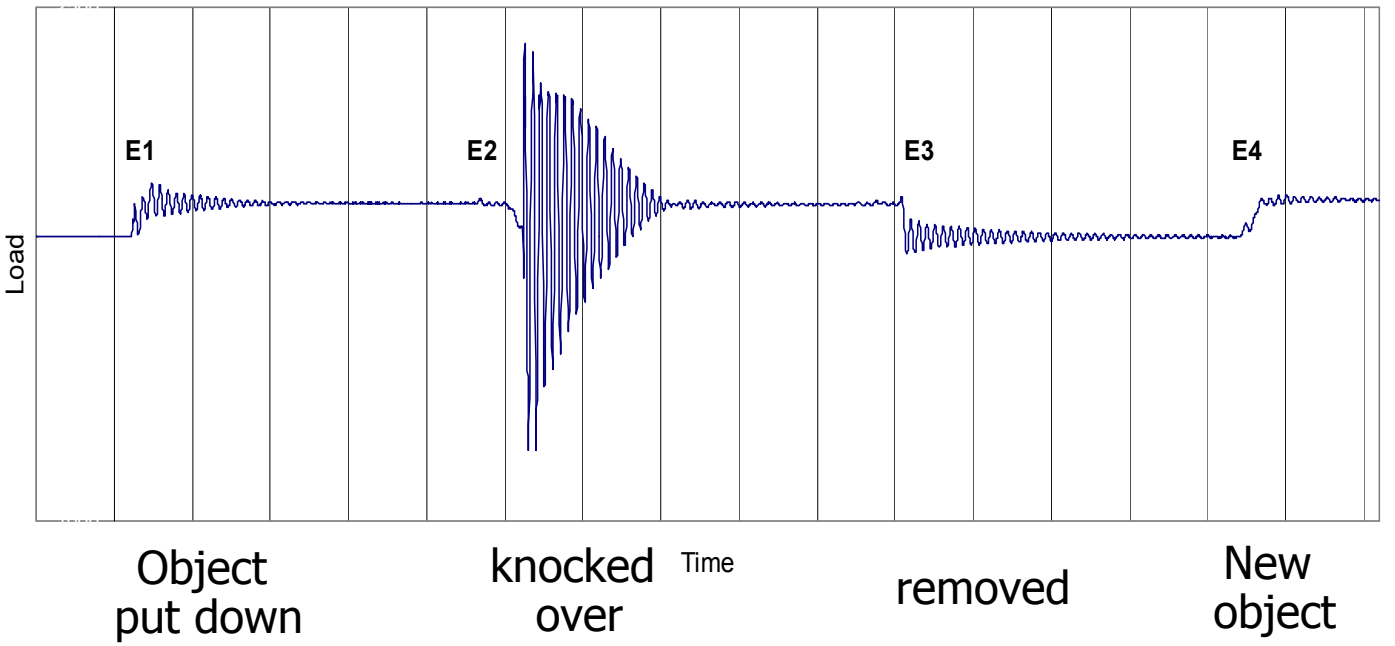
Context Acquisition

- Weight of objects
  - Detection depends on sensor range (i.e. small weights not detectable on heavy-load surface)
  - Application: object identification (classes/ instances)
- Position of objects
  - cm-level accuracy
  - Table can be pre-loaded
  - Multiple objects can be positioned if placed non-simultaneously

Load-Sensing Surface

Context Acquistion

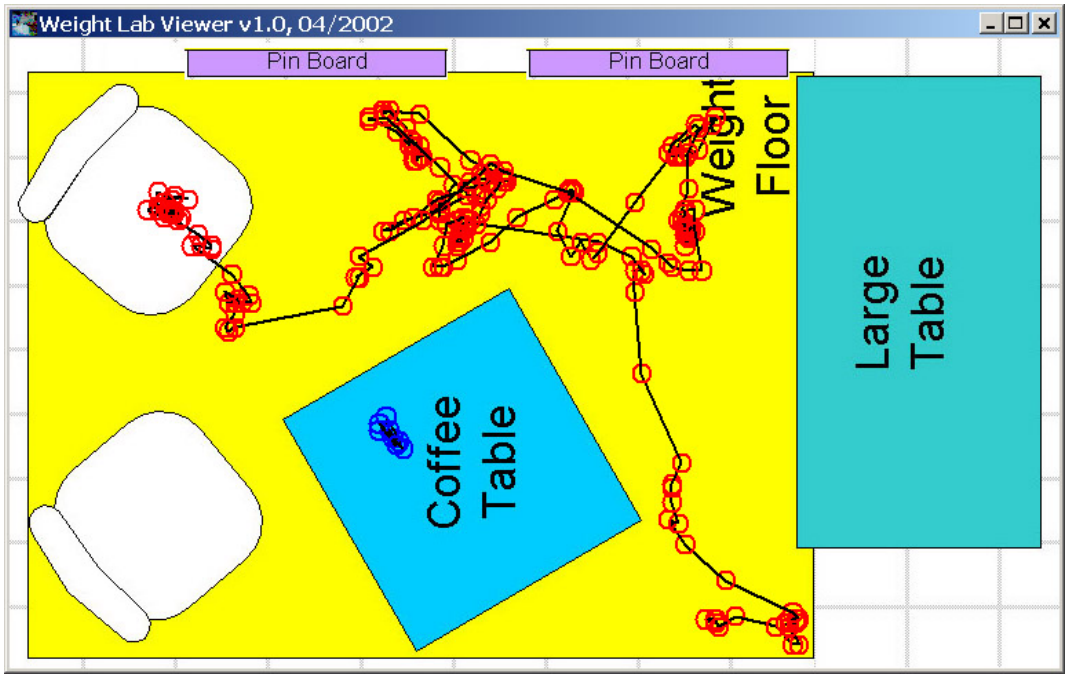
- Beyond weight and position: events derived from signal analysis over short time



Load-Sensing Surfaces

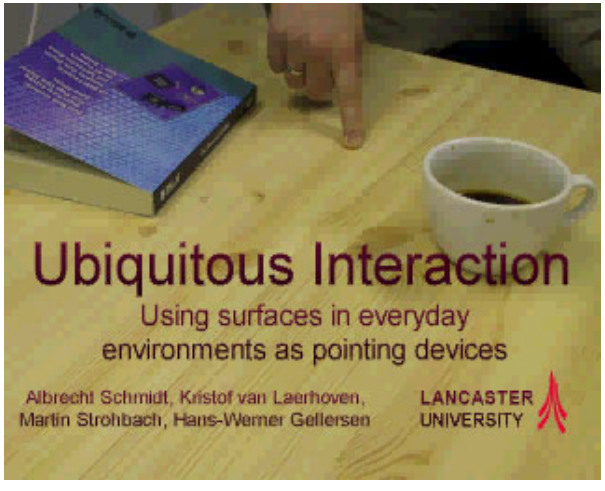
Context Acquistion

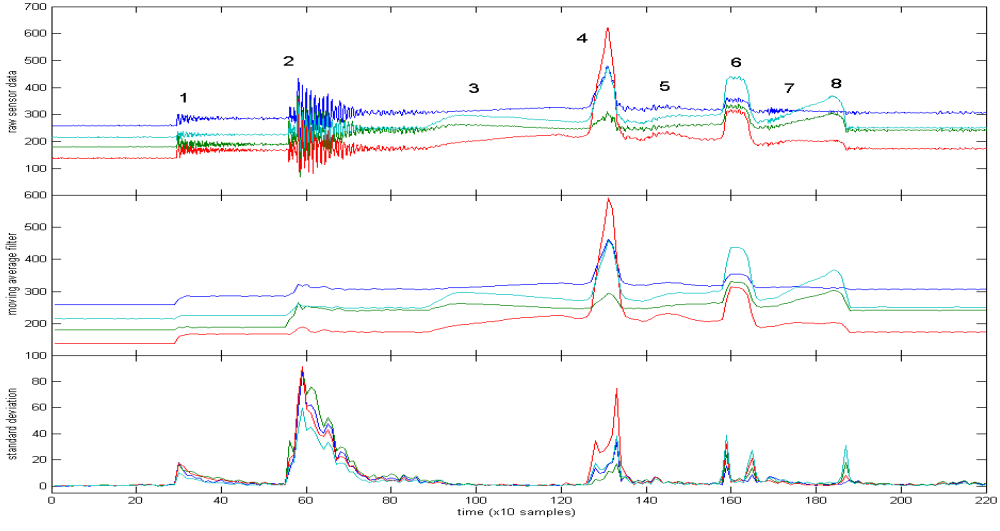
- Tracking of people/objects
- Prediction of activities



Load-Sensing Surface

Surfaces as Interaction Device





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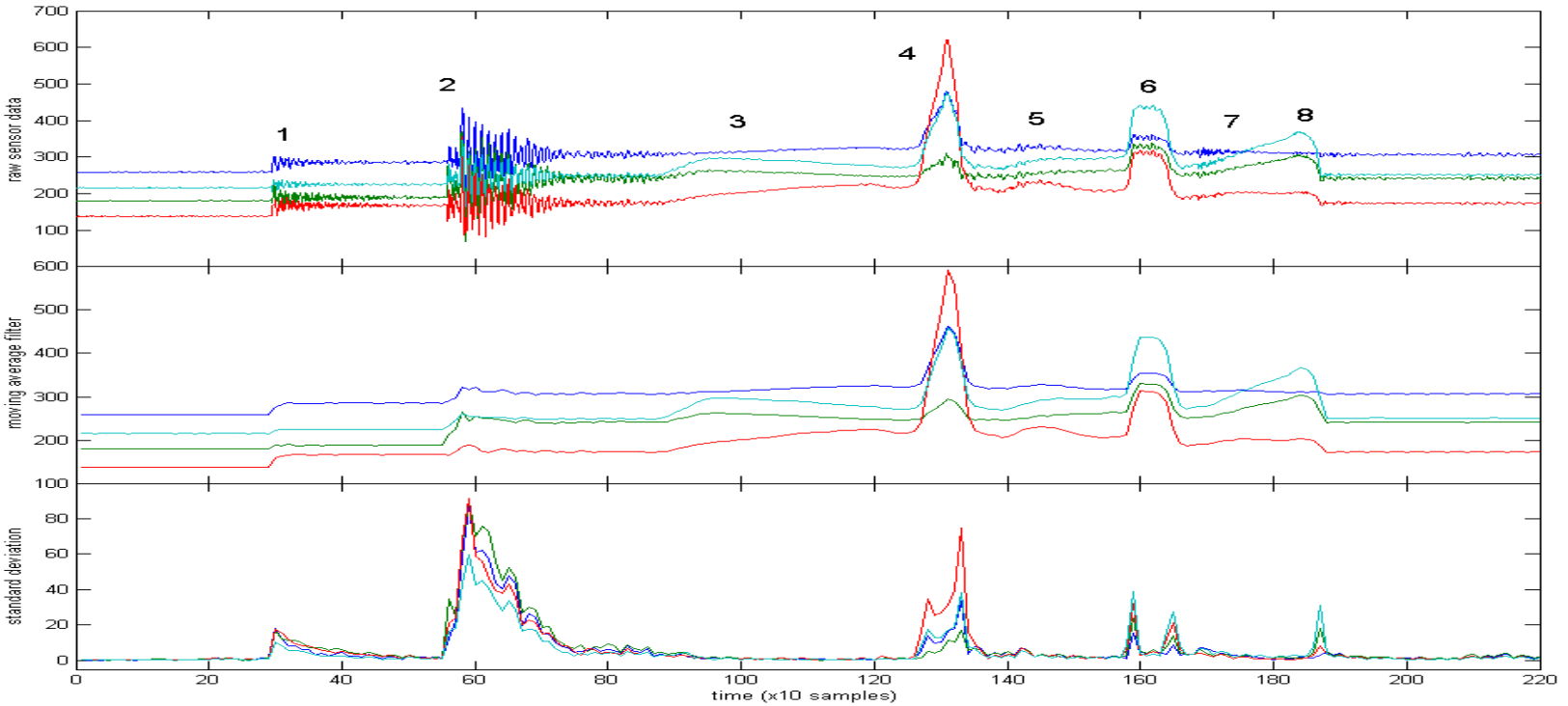
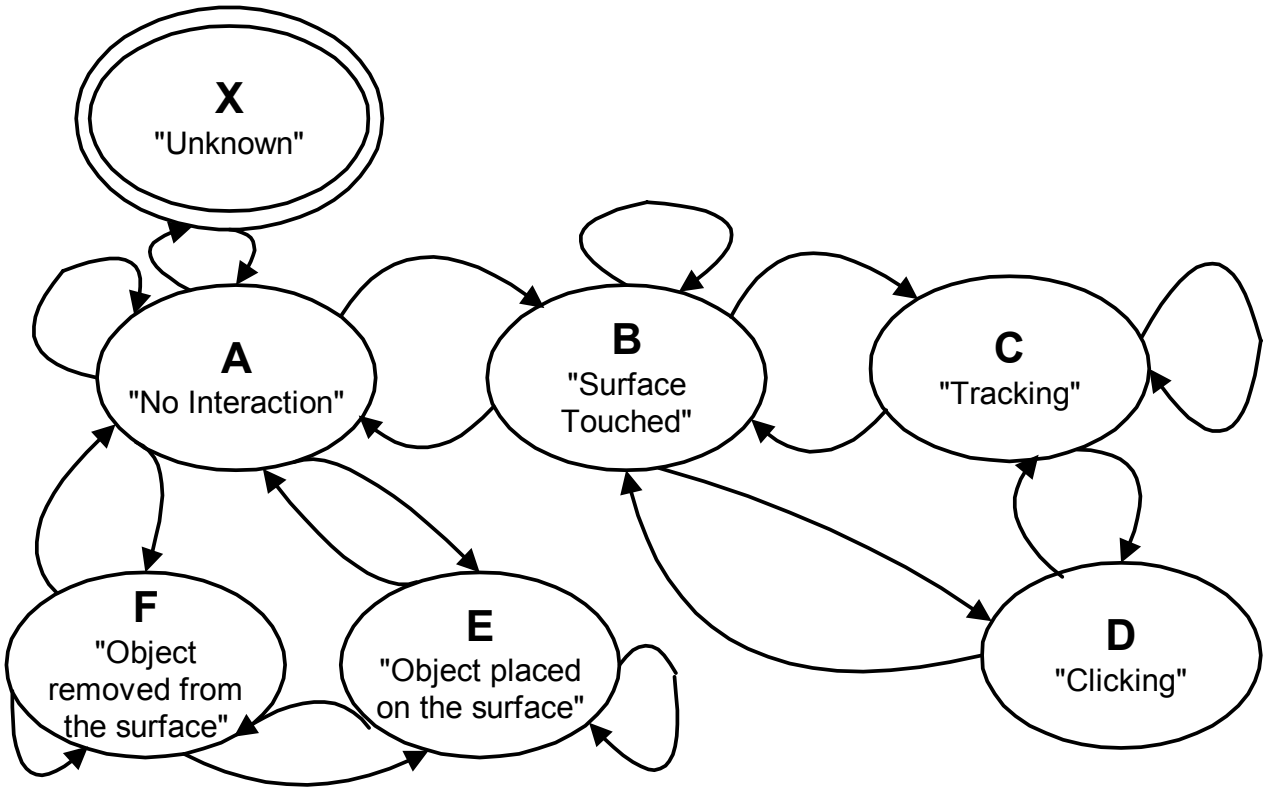


Load-Sensing Surface

Surfaces as Interaction Device



Summary

Computer-Augmented Environments

- Build on familiarity and meaning of existing artefacts / structures
- Introduce digital added value in the background

Pin & Play, Load-sensing surfaces

- Examples for network/tracking infrastructure integrated with common structures and everyday uses
- Low-tech, unobtrusive design