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# Engineering Interactive Ubiquitous Computing Systems

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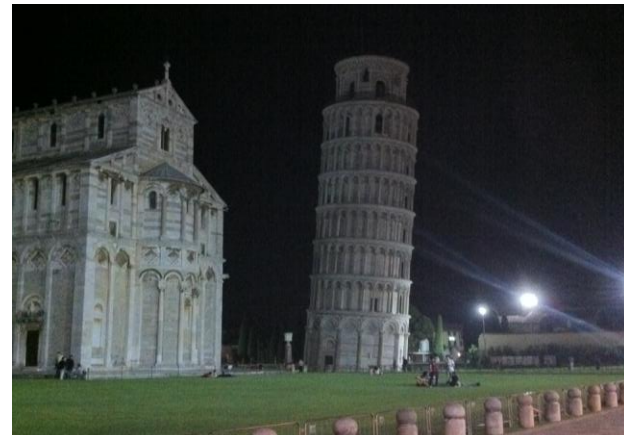

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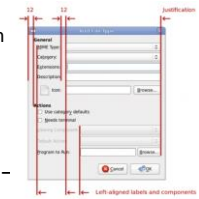
## Overview

- **Why to look beyond desktop and mobile user interfaces?**
- Embedded computers are everywhere
- Ubiquitous Computing is becoming reality
- Cars are Ubicomp environments – a case study
- Defining trends for the future
- A vision for computing in the future - unlimited perception
- Lessons learned



"I would imagine that by now developers specify user interfaces on an abstract level…"



"software developers have moved from machine language and assembly to high level languages, toolkits, and frameworks – why are UI developers still talking about pixel spacing?"

"the ubiquitous pinch gesture on touch screens is the proof that content transformation has failed…."



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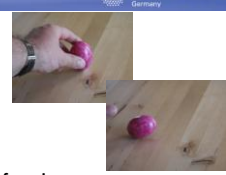
## Issues with HCI as a Scientific Discipline



**Problems** the discipline is concerned with are **understandable by anybody**

**Solutions** to the problem appears **obvious once found** (at least in an optimal case)

Once a solution is there it is not recognized that there was a problem

process from **problem to solution** is non-trivial…



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## The quality* of desktop user interfaces in 2011 is way better than the desktop UIs in 1991


**and quality has many aspects including usability, learnability, and efficiency*

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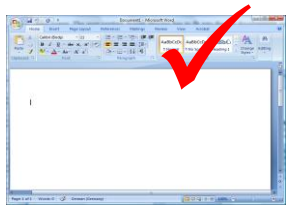
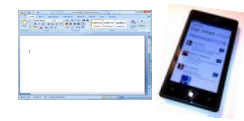
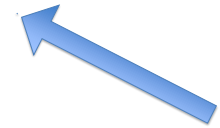
## Desktop and mobile is done… lets move on









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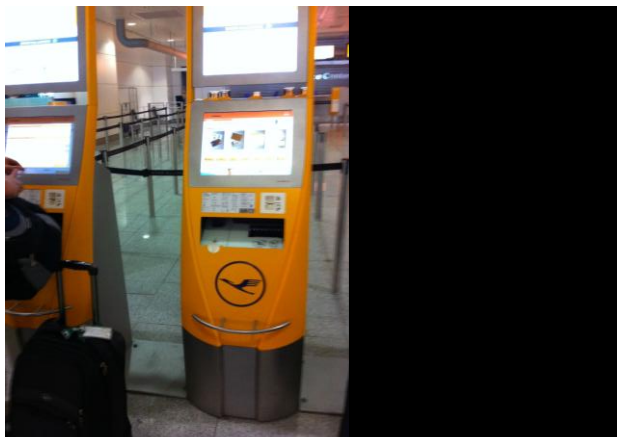
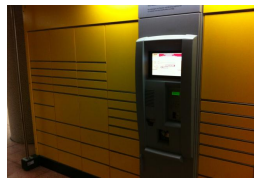


## Desktop computing in disguise?







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## recently was going to a family event – having 3 GPS units with me … **and I was not the only one**







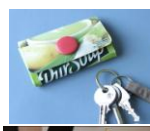
## Computing is everywhere

Many devices to come!

Everything that is valuable may include mobile communication and tracking.

Who will create the basic hardware platform?

How will the meta service platform look like?





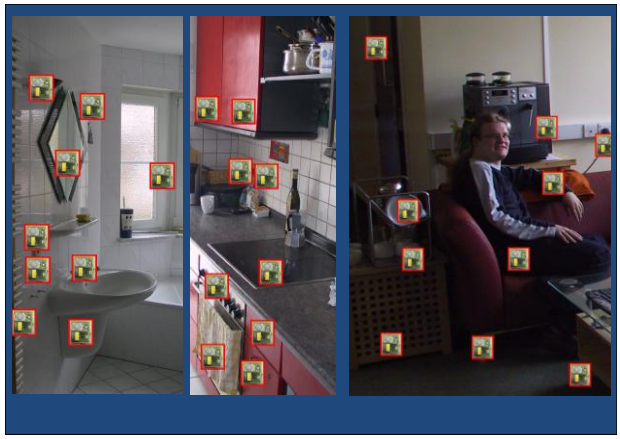


## Some Building blocks for Ubicomp

- When will a OEM-device that includes…
  - GPS
  - Acceleration sensors
  - 3G data connectivity
  - Battery
  - … connectivity for I/O

…be less than 10€|3€ (in large quantities) and less than 50g|20g?

(and perhaps we can do power harvesting, too)







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## Engineering Novel User Interfaces
## A Case Study: *Gazemarks*

- An idea to start with…
- Ethnographic observation
- Formative study
- Systematic design of the user interface
- Implementation of a working prototype
- Rigorous evaluation and analysis
- Provision of guidelines, components, toolkits







## Gazemarks
### Motivation

- Reading while you drive?
- Looking for your way while driving?







## Gazemarks
### Ethnographic Observation and Formative Study

People use fingers and objects as markers in tasks that require attention switching.

- Study task: compare two telephone lists (40 names, one list on paper and one on the screen)
- 30 participants (volunteers; 10 female, 20 male; aged 23 to 61)
- Participants were not aware of the research question
- No time limit was enforced and time was not measured

- 22 out of 30 used fingers and/or objects to remember their last position on paper list
- 8 out 30 used fingers, objects, or cursor on the digital list

# Gazemarks

## Create this functionality in the digital world

- Idea: provide a visual feedback on digital documents to ease attention switching
- Technology: eye gaze tracking

- Example Domains:
  - Multi-screen setups with simultaneous visibility of documents
  - In-car information and entertainment systems that are used while driving
  - Switching between multiple documents of which only one is visible at the time (e.g. tabs in a browser)
  - Information terminal in an operating theater, which is used while working on the patient

Approach: detect last gaze position before the attention switch and highlight this area till the gaze returns

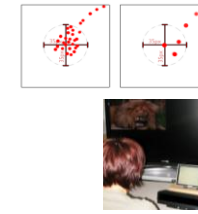


# Gazemarks

## Basic parameters

Approach: detect last gaze position before the attention switch and highlight this area till the gaze returns

- What is a gaze fixation?
- How long is the last conscious gaze fixation?
- How can we detect a fixation in the gaze data?
- How can showing a visual placeholder be avoided after a blink?







# Gazemarks

## Visual Representations

- Focus group with 6 people to choose the visual representation
  - Flag
  - Spotlight
  - Focus area
- Questionnaire to express a preference
- Spotlight before Focus area and Flag
- Spotlight
  - Easy to find
  - Perceived a precise
  - Not hiding any information



# Gazemarks

## Implementation

- Hardware
  - Commercial eye tracker
  - Tobii X120 (with a data rate of 120Hz),
  - PC with a 42" display and an 8" display
  - Networked over LAN
- Software/Middleware
  - EI-Toolkit (component based architecture)
  - Proxy for the Tobii eye-tracker
  - Message exchange via UDP
- Test Application
  - Java application implemented for the experiment




# Gazemarks

## Experiment

- Setup
  - 2 screen setup
  - Map search task on small screen (6 letters with 8 numbers each)
  - IQ questions on large screen
- Design
  - Within- group, each subject complete both task in counterbalanced order
  - Procedure: Find given letter, attention switch, find given letter again
  - Independent variable: visualization (Spotlight vs. no visual aid)
  - Dependent variable: search time (limit 3000 ms)
- Participants
  - 16 volunteers (23 to 52 years old)




# Gazemarks

## Results

- Participants were considerably faster in searching with *Gazemarks*
  - with *Gazemarks:* 625.75 ms (median)
  - without *Gazemarks* :1999.50 ms (median)
- Comparing search times
  - non-parametric Wilcoxon signed-rank test
  - $p<0.001$
- Qualitative results
  - Preferences for *Gazemark*
  - Mean value 4.26, standard deviation 0.53, on a scale from 0 (completely senseless) to 5 (very sensible)
  - Reported benefits as perceived by the user: enabling rapid task switch and less attention required

## From Engineering Novel User Interfaces

- An idea to start with…
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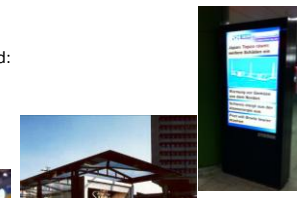
**…to Engineering Interactive Systems**



## Engineering Interactive Systems

- A new communication media
- Besides Interaction – understand:
  - all stakeholders
  - business case



pd-net.org



## Engineering Interactive Systems is about the (measurable) values you create



## Systems are part of people's lives

**Measurability!**

- Increasing the **efficiency** of work processes
- Minimizing **human errors** in interaction with systems
- Increasing the efficiency of **education and training**
- **Reducing the cognitive load** (or stress level) for a task
- …
- Making interaction more **enjoyable**
- …
- Improving **safety** when using systems
- Creating systems that are "**natural**" and "**intuitive**" to use



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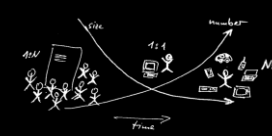
## Ubiquitous Computing Trends

Enabling Smart Devices & Intelligent Environments

- **Processing**
  - cheap, fast, small, energy efficient
- **Storage**
  - big and fast
- **Networking**
  - global, local, ad-hoc, low-power
- **Displays**
  - projection, flexible materials, power consumption
- **Sensors**
  - types, speed, accuracy, price
- **Actuators**
  - many, computer controlled

*"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)*





# Communication Networks

## Ubiquitous & Global

driving new devices and applications





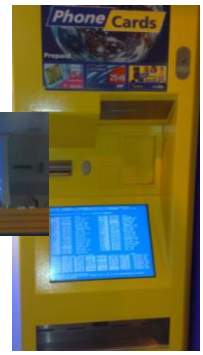
## classical computing limitations will play very little role in the future for consumer devices

we will be so used to having bandwidth, memory and processing in excess that we may forget the terms…





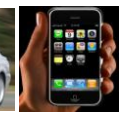
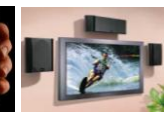
## Computing and infrastructure has become invisible to the user – at least as long as everything works








## Innovation is in software User Experience to differentiate


Software will become a main feature and value generator in many areas that are till now “non electronically”

**… the design and UI may be the only discriminating factors to work with**





Embedded

Wearable

Social


# Ubiquitous Sensing

Participatory

Physiological

Environmental







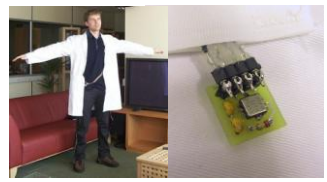
## Our understanding of privacy, and what we consider private will radically change

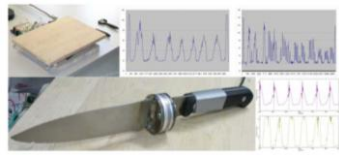


our personal information will likely become a commodity that we trade…

Ethics & privacy become design material

## Aware – Everything






## People share their experience




- In real time
- everywhere
- Un-filtered
- Reaching potentially a large audience
- Risk and opportunity

twitter





## Products and Services a means self-expression



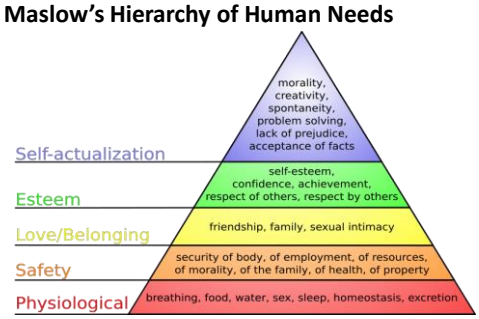









## "Long lasting constants" Maslow's Hierarchy of Human Needs





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A Vision for Computing in the future

# Perception beyond the here and now

… about perception and technology

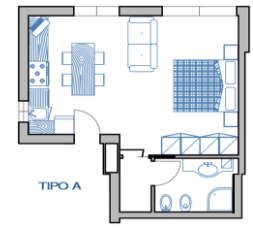
**What is the difference between driving 140 km/h on the motorway in a 10 year old VW Polo compared to at current model Audi A8?**







## Communities of the future




(selectively) sharing a one-room-apartment with all your “friends”

















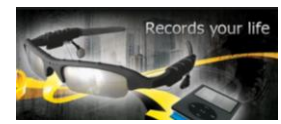







## Scenario

100 million people stream their 1st person view in real-time




Support for real-time as well as archive access

Indexed by location, co-location, events, context-information, …

## Perception beyond the Here and Now

By the middle of the century the **boundaries between direct and remote perception** will become **blurred.** By the it will be hard to discriminate real-time perception apart from historic content or future predictions.



## Perception beyond the Here and Now

Masses of networked sensor-equipped computing devices are **overcoming longstanding temporal and spatial boundaries to human perception**



## Perception beyond the Here and Now

**Ethics** and values are the central **design material** of this century



## What are the implications for the people working in HCI if computing becomes the window to and manipulator for the world?



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Lessons learned: **implement it and try it out!**
Novel Interaction Techniques on PDAs
Context-aware Phone my initial experience (1998)

## Lessons learned: **Be happy if 20% like it**

Context-Call and Context Phonebook (2000/2001)














## Lessons learned:

**Humans are "adaptive systems" hence creating adaptive system is tough…**

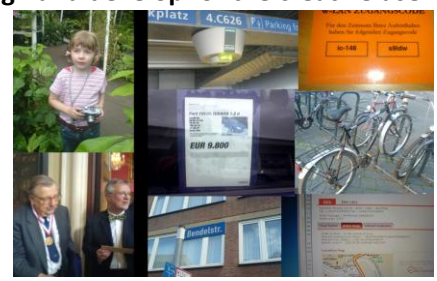






## Lessons learned:

**Design and develop for the creative user**










## How to do research on novel ubiquitous user interfaces?

- Create a new experience and a new value
  - Explore something that has become possible that was not possible before
- Make use of the many people out there (twitter, facebook, Mechanical Turk, etc.)
  - creating requirements, explore designs, evaluation, …
- Make the full use of (novel ) modality
  - Technology will not be the limiting factor (e.g. Kinect)
- Understand and Combine implicit and explicit interaction
- Find something REAL you can measure
  - measurability is key otherwise your will design "something







## Questions? Comments?

**Novelty may be about the values/ethics**

Lessons learned:

**Implement it and try it out!**
**20% who like the UI are a large market**
**Humans are smart and adaptive**
**Design for creative users**

Visit my websites at:
http://albrecht-schmidt.blogspot.com/


Albrecht Schmidt, Marc Langheinrich, Kristian Kersting, "Perception beyond the Here and Now," Computer, vol. 44, no. 2, pp. 86-88, Feb. 2011, doi:10.1109/MC.2011.54







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