Instrumented Environments
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Mon, 10-12 Uhr, Theresienstr. 39, Room E 46
Topics Today

- Actualities
  - Instrumented environments seen in Korea
  - Notion of “Ubiquitous robots”

- Some network technologies for IE
  - Wired
  - Wireless
  - Optical

- Some positioning technologies
Instrumented Country?!?

- Car info system
  - Position via GPS
  - Map data via mobile net
  - Device cost ~200$
  - Subscription ~30$/year

- Services:
  - Speed limits:
    - Cameras + distance
    - Actual measured speed
  - Sharp turns, bends, stops, traffic lights
  - Navigation if connected to a Laptop

- Interface:
  - 3 digit LED display for speed
  - Use of „sound icons“ (3 beep = 300m, 2 beep = 200m)
  - Speech output (constant chatter!)
Instrumented Bedroom

- Support for disabled people
  - Robot person lift
  - Robot wheelchair
  - Robot bed
  - Fridge/oven combi
  - Sensing mattress

- Interface:
  - Control via voice input
  - Feedback via talking head („yes, master..“)
  - Gesture input (e.g., for TV for spastic patients)
**Instrumented Bedroom (2)**

- Patient can move betw. bed + wheelchair
  - Wheelchair will come automatically
  - Lift will act on commands
  - Bed will adapt shape on command
  - Fridge will heat up meal

- Sensing mattress can tell whether...
  - patient is in right position
  - patient has fallen off

- Safety + self-determined life
  - Nurse not constantly needed
  - Environment can call if there seems to be a problem
  - Sense of Mastery („yes, master..“)

http://hwrs.kaist.ac.kr/
More medical robots…
Robot shapes
Large humanoid robots
Robot disciplines

- RoboMarathon (42.2m way following)
- RoboBalancing - Beam
- RoboDancing
- RoboWeight-Lifting
- RoboBoxing
- RoboBasketball
- RoboSoccer in different leagues

- Dash (walk forward and backward)
- Stair climbing
- Search and rescue
- Mine sweeping

- www.iroc.org
Notion of Ubiquitous Robots

- Three types of robots:
  - SoBot: software agent
  - EmBot: embedded device
  - MoBot: mobile robot

- SoBots can...
  - roam among machines
  - talk to other sobots
  - learn about environment and users
  - use EmBots or MoBots as their „body“
  - adapt to „senses“ and „limbs“ of the „body“
Now: back to earth....
Some wire-based network technologies for IE

- Ethernet (classic and mostly used today)
- 1-wire bus (for small & low power devices)
- Powerline (for instrumented homes)
Ethernet (here: 10Base2)

- Developed by Bob Metcalf (Xerox PARC)
- Open standard since 1980 (DEC, Intel, Xerox)
- IEEE standard since 1986
- Main Components:
  - Physical medium (cable)
  - Access rules inside the Ethernet interface
  - Ethernet frame with well-defined number of bits
- No central component
- Solve collisions by random

First sketch of the Ethernet by Bob Metcalf in 1976
1-Wire bus

- Ethernet needs a separate power supply for each connected device
- Problem with Ubicomp: lots of small devices with low power consumption
- Solution: Use the data cable to supply power (i.e. power over Ethernet or 1-Wire bus)
- 1-Wire bus needs only one cable (+ ground)
1-Wire bus

- Developed by Dallas Semicond.
- Bidirectional communication
- “master” provides “slaves” with power

- The slave obtains power over the data cable
- The slave uses a capacitor to store the energy needed for proper operation (starting with 2.8 Volts)
- To send a logical 1: pull down voltage on data cable for less than 15 µs and…
- To send a logical 0: pull down voltage on data cable for more than 60 µs
1-Wire bus

- Each slave has a unique (48-bit) Id
- Different types of slaves are available: NVRAM, EEPROM, temperature sensors, simple clocks, etc...
- Data cable may reach up to 300 meters
- Theoretically infinite number of slaves, but since reading is sequential there is a practical limit (e.g. Reading of 500 ids takes approx. 12 s).

- Some applications:
  - identification of persons
  - sense real world states
- Advantage: Integrity of data cables can be tested easily.
Power Line Communication

- Uses existing in-house power cables
- E.g., PLC-ethernet bridge with 14MBit/s
- Some Applications:
  - LAN, Internet access
  - Telephone – Voice over IP
  - Video on Demand, surveillance
  - Reading out energy counters
  - Remote control of devices
- [http://www.homeplug.org/](http://www.homeplug.org/)
Problems of Power Line

- Quality of connection depending on
  - Different circuits and phases (fix by adding a capacitor between them)
  - Background noise
    - Household appliances: e.g. TV, Radio (narrow bandwidth noise)
    - Electrical engines (e.g. drill, broad bandwidth noises)
    - Switches (e.g. for lights, single bursts)
Radio-based technologies

- Large cells (>100 m): e.g. WLAN, GSM, UMTS
- Small cells (10 - 100 m): e.g. Bluetooth
- Very small cells (1 - 30 m): RF module
WaveLan IEEE 802.11b

- Basically like ethernet on air (2.4 GHz)
- All stations send and receive on the same frequency.
- Repetition on collision
- High frequency means small range (50-500 m)
- Advantage: already widespread

**Idea:** radio networks with small range replace today’s cables and provide a bridge to existing networks.

**Examples:**

- BT Headset for mobile phones
- Phones, Fax, PDA, Computer, keyboard, printer, joystick, fridge, microwave, heating, car.....
Bluetooth

**Principle:** establish, enlarge and shut down ad-hoc networks, depending on proximity of Bluetooth enabled devices

**Technical facts:**
- Speed: ca. 1 MBit/s
- Size of cell: 10 or 100 Meter
- Frequency: 2.4 GHz

**Consortium:** 3Com, Ericsson, IBM, Intel, Lucent, Microsoft, Motorola, Nokia und Toshiba
Bluetooth Pico-nets
(ad-hoc networking)

Each Pico-net has one master and up to 6 slaves
Frequency Hopping

- Schema-based change of frequencies
- Fast hopping and small package sizes reduce the probability of collisions
Bluetooth Specification (part of) Protocol Stack
Bluetooth Profiles

Each profile is a vertical cut of the Bluetooth protocol stack.
Problems of Bluetooth

- Lots of noise on 2.4 GHz (e.g. microwave oven and WLAN)
- Small bandwidth (worst case < 1/7 MBit/s)
- Still less widespread than infrared (on European and American market)
- Still complicated interfaces
  - Inconsistency of supported profiles
Small RF Devices

- Cheap solution, needs individual adjustments
- Small range (1-30m), low power consumption
- low bandwidth: 115 KBit/s
- Small form factor
- Examples:
  - Smart-Its
    - [www.smart-its.org/](http://www.smart-its.org/)
  - Berkeley Motes
    - [www.tinyos.net/](http://www.tinyos.net/)
Infrared communication

- Uses non visible light (900nm)
- Does not travel through objects (needs line of sight)
- Analog: IrRemote
  - Modulated carrier
  - Good range (up to 20 m), small bandwidth
- Digital (IrDA)
  - Uses single light flashes for 1 and 0
  - Small range, high bandwidth (up to 4 Mbit/s)
  - Bidirectional communication between 0 and 2 meters
IrDA

- Founded 1993 as an organization, which defines an independent open standard
- The goal was to realize simple point to point solutions to connect devices.
- Protocol stack simpler than Bluetooth
  - LAN
  - Serial
  - ObEX

![Diagram of IrDA protocol stack](image)
Long range connections with IR

- Parctab Communication Hub
  - Range 7m
  - Bidirectional connection
  - 9.600/19.200 baud
  - analog IR

- Eyeled Sender
  - Range up to 20 m
  - Bi/Unidirectional connection
  - 115 Kbaud
  - IrDA compatible
Broadcasting structured information

- Cut down presentations to small packets (similar to Videotext)
  - Use different interaction levels
  - First package starts at level 0
  - => Conceptual presentation graph

- Transition between levels:
  - Qualitative change of information
  - additional information
  - more general or detailed information
Example: Presentation graph
Ideal transmission scheme

- Continuous transmission cycle
- Arbitrary entry point
- Quick availability of level 0
- Levels >0 may take longer
  - Can only be reached by interaction
  - Hide transmission time behind interaction time
Probabilistic transmission scheme

\[ w_{ik} = \frac{1}{c^{i+1}}, c \geq 1 \]

\[ S = \sum_{i} \sum_{k} w'_{ik} \]

\[ w_{ik} = \frac{w'_{ik}}{S} \]
Personal Area Network (PAN)

- Idea: use the body to transmit information
- Use currents in the nanoAmp. range
- First at MIT (Thomas Zimmer, 1995) then IBM, Intel, Univ. of Washington
- Used in human-human and human-environment communication
- Example: exchange business card while shaking hands.
- Built-in security!

Figure 5: Locations and applications for PAN devices include head-mounted display, headphones, identification badge, cellular phone (in waist pack), credit and phone cards (in wallet), watch with display, microphone and speaker, and "power sneakers" (self-powering computer shoe inserts).
Some positioning and tracking technologies for IE

- Types
  - Cells
  - Signal strength
  - Signal runtime
Cell-based Localization

- Each sender has a unique Id, which can be identified
Radio transmission (large cells)
Radio transmission (small cells)
Infrared transmission
Measuring signal strength

- **Radio:**
  - Triangulation: approximate the distance by measuring the signal strength from several senders
  - Signal strength is heavily dependent on the environment (radio)

- **IrDA:**
  - no measurement of signal strength possible

- **Acoustics:**
  - problems with noise
  - Precision highly variable

- **Machine Learning approaches possible**
GSM + DAB

DAB = Digital Audio Broadcast
Positioning by signal runtime

- Measuring signal runtime from known senders
- More accurate than signal strength measurement but also more difficult

Problems
- Radio: Multi-path, atmospheric distortions
- Good placement of senders necessary

Enhance results by introducing reference points
Global Positioning System (GPS)

- one satellite
- two satellites
- three satellites
Differential GPS

- Enhancement of precision by using a correct reference signal
  - Need to know the exact position of a receiver
  - Send the difference between actual and measured position to the mobile device

- Problem: Delay of correction signal

- Used to be important because of errors (300m) induced into GPS by US military
Pseudolites: artificial GPS Satellites (IntegriNautics)

- For areas with low GPS coverage
- High precision
  - Automatic farming, landing airplanes
- Use together with standard GPS receiver
- Problems with indoor use
  - Overriding signals
  - Multipath effects