Sensors for UIs

(Physical & Tangible User Interfaces)

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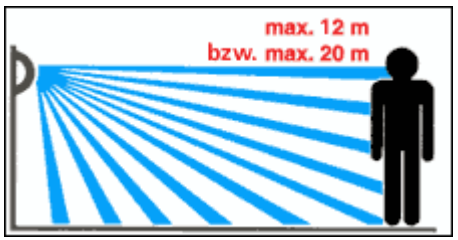
Implicit Interaction and Sensor-based User Interfaces

- Implicit Interaction – user is observed by the system
- Example: outdoor light in front of the house that switches on when someone walks by
- Sensors:
  - light level
  - activity
- Actuator
  - light (on/off)
- Rules
  - if (dark & movement) then light(on)

Is it as simple as it looks?

More design decisions!
e.g. when switch it off?



Perception in Creatures

- Vision
- Hearing
- Smell
- Taste
- Touch
- Temperature
- Gravity and acceleration
- Position and constellation of (body) parts
- General magnetic fields and in particular the magnetic field of the earth
- Electric fields

Motivating the use of Sensors
Contexts related to sensory input

Context	*Related sensory input*
User sleeps	It is dark, silent, type of location is indoors, time is “night-time”, user is horizontal, specific motion pattern, absolute position is stable
User is watching TV	Light level/colour is changing, certain audio level (not silent), type of location is indoors, user is mainly stationary
User is cycling	Location type is outdoors, user is sitting, and specific motion pattern of legs, absolute position is changing.

Technologies for context acquisition

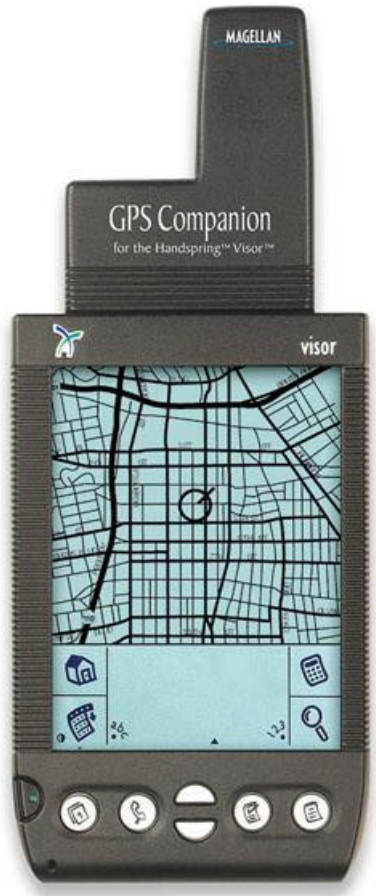
SensingTechnologies
Light and Vision
Audio
Movement and Acceleration
Location and Position
Magnetic Field and Orientation
Proximity, Touch and User Interaction
Temperature, Humidity and Air Pressure
Weight
Motion Detection
Gas-Sensors and Electronic Noses
Bio-Sensors
Zero-Power Sensors

Sensor don’t come for free
Constraints on Sensing

Requirements on Sensing in a Ubiquitous Computing
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

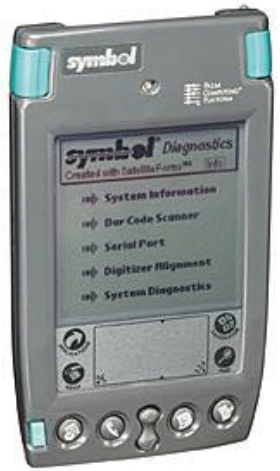
Location Information

- Get location via GPS
  - Magellan GPS Companion for Palm PDAs
  - Has its own battery
  - Lasts for about 10 hours permanent usage
- Wavelan
- Mobile Celluar Network



ID Sensors (Barcode, RFID)

- Get identification via Barcode or RFID Reader
- Symbol SPT1500 Palm Scanner reads UPC/EAN/JAN, Code 128, Code 39, Code 93, Interleaved 2 of 5, Discrete 2 of 5, Codabar, MSI Plessey
- GD-CF1 is a RFID compact flash reader for reading/writing of 125 KHz transponder

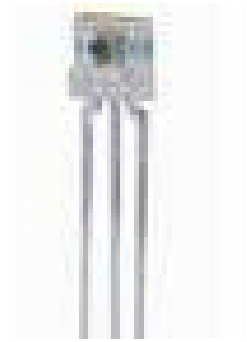


Palm-integrated BarCode Reader

GD-CF1 attached to a Pocket PC

Light Sensors

- For various wavelength (IR, UV, etc.)
- Information about intensity, direction, reflection
- Distinguish between different types of light (sunlight, candle light, artificial light...)
- Low cost, low energy consumption



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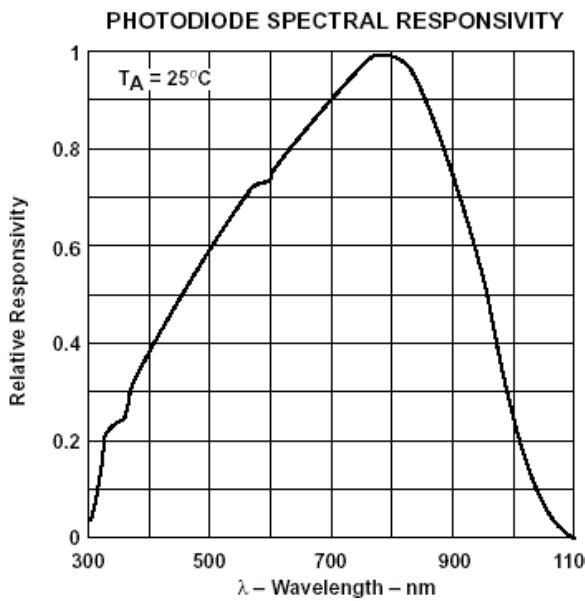
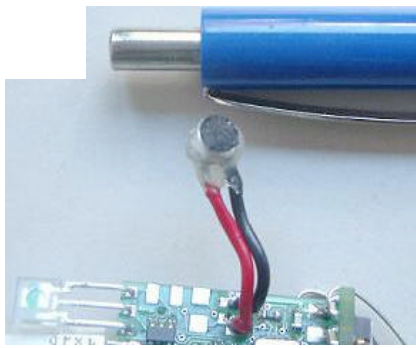


Audio Sensors

- Microphones for human hearable audio
- Special sensors for ultrasonic
- Get basic information such as noise, sound level, type of input (noisy, music, speaking), base frequency (requires simple calculations)
- Complex audio analysis by speech recognition (requires more processing power)
- Multiple microphones (arrays or distributed) for determining sound direction, distance, and even location

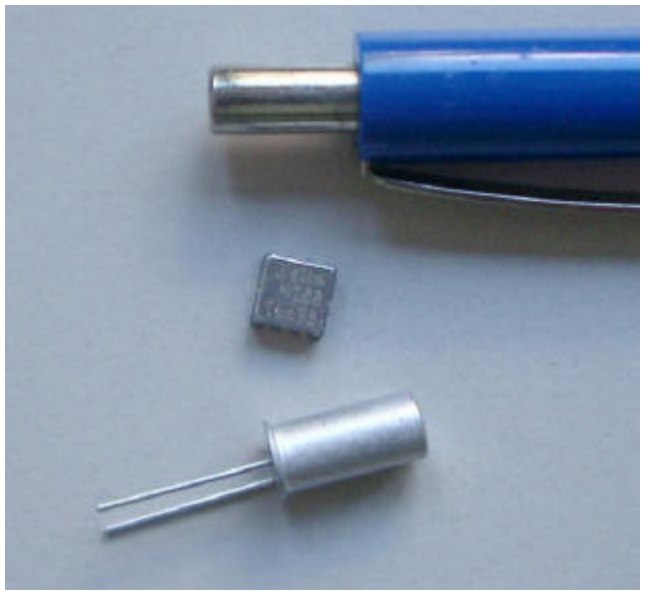
microphones



Ultra sonic sender/receiver
by lynxmotion.com

Acceleration / Movement

- Different type of sensors for basic information like inclination, motion, vibration and acceleration
- Sensors are ball switches, angular sensors, accelerometers
- Information like type of motion (car driving, walking, running, stationary) and orientation in space can be derrived
- Acceleration is especially interesting in examination of usage patterns



ADXL acceleration sensor and ball switch

Further Physical Properties

- Temperature
  - Cheap
  - Monitor body heat
- Touch
  - Directly, i.e. with conductive planes (e.g., skin conductance, human as capacitor) or force sensors
  - Indirectly, i.e. using light sensors or temperature sensors (energy issue)
  - Usage as switches or derrive information about handling a device

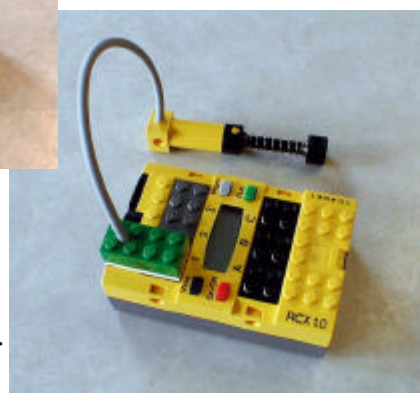
Truetip.com

Force sensor (flexible resistor)

Further Physical Properties

- Magnetic Field
  - Magnetic field sensor works similar to a compass
  - Detects direction or direction changing (movement)
  - False information because of interference by other devices
- Air Pressure
  - Indication of altitude
  - Detects changes in the environment e.g. closing a door

zoom-one.com



LEGO Air Pressure Sensor (techo-stuff.com)

Activity and Presence Sensors

- Proximity/Vicinity (Passive IR)
  - Motion detection by body heat
  - If sensor is mobile the movement of the device itself is detected

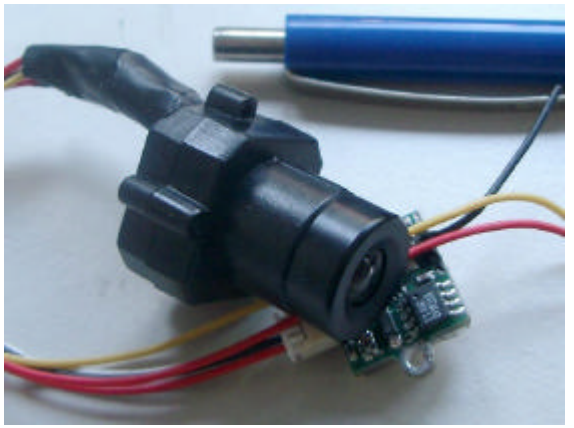
domesticspy.com

PIR Sensor

- Login-Information/Profiles
  - Identify the user of a system
  - System is able to load presets
  - Personalization

Visual Sensors

- C-MOS Camera
  - Captures visual information
  - Basic information are for instance amount of motion, light level (require little processing power)
  - Complex information like object identification and tracking, gesture recognition (require more processing power)
  - Discomfort problem because of being watched
- OCR (Optical Character Recognition)
  - Graphical Symbols are interpreted as letters and words by a computer
  - Preferred way to enter text into PDAs



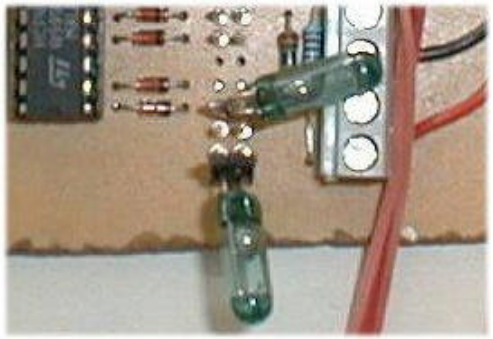
Wireless CMOS Camera

Microsoft Transcriber on Pocket PC

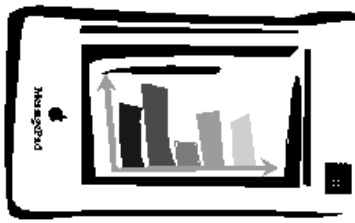
Examples of Sensor based UIs

Orientations aware PDA

(my first sensor-based UI)



Portrait



Landscape

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

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.

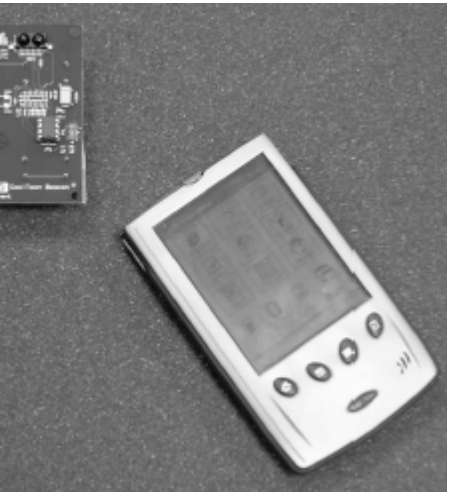
Applications

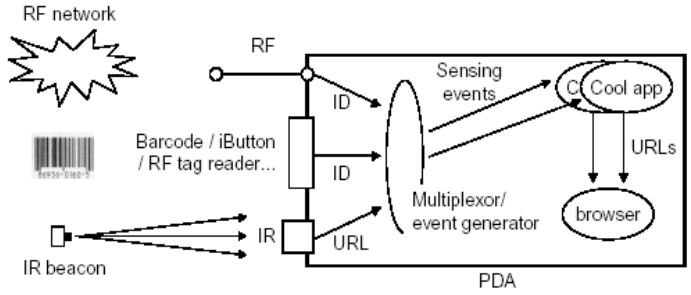
- user interface adapts to situations/context
- Implemented example applications
  - automated profile chang
  - context sharing
- Recognized contexts
  - hand
  - table
  - Suitcase
  - wardrobe
  - outside

WebSign (HP)

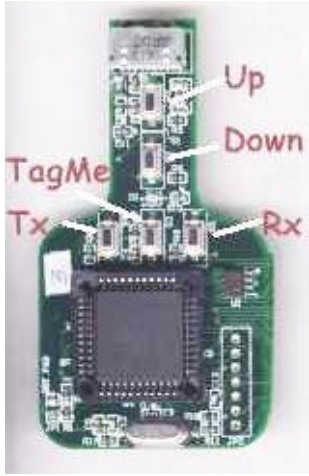
- PDA with location, orientation, and tilt-angle
- Showing information that about the object you are pointing at
- Cooltown Project

Prototype Websign client with magetometer, GPS receiver, and the websign kernel





PDA with IR Beacon (left) and PDA sensing platform (right)



IR Taggy, a personal device which stores and squirts references (URL)

A.Schmidt, C.Decker, Mensch & Computer 2003, Stuttgart

Sensing Techniques for Mobile Interaction

- Hinckley et al.
- Video (3 min)

Further Reading

- A. Schmidt, K. Van Laerhoven. **How to Build Smart Appliances?** *IEEE Personal Communications* 8(4), August 2001.pp. 66-71.
- Hinckley, K., Pierce, J., Sinclair, M., Horvitz, E., ***Sensing Techniques for Mobile Interaction***, ACM UIST 2000 Symposium on User Interface Software & Technology, CHI Letters 2 (2), pp. 91-100. **Best Paper Award of UIST 2000.** [MPEG Video – running time 3 minutes, 15 sec] [PDF] [PDF for color printer]