

# Interaction with the Physical World

Methods and techniques for sensing and  
changing the environment

# Sensing and Changing the Environment

- Light
- Motion and acceleration
- Sound
- Proximity and touch
- RFID

# Sensors and actuators for UIs

- Sensors and actuators are examples of **transducers**

A transducer is a device that converts one physical quantity into another

- examples include:
  - a mercury-in-glass thermometer (converts temperature into displacement of a column of mercury)

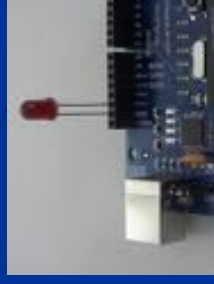
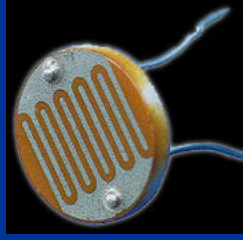
- Almost any physical property of a material that changes in response to some excitation can be used to produce a sensor

# Physical I/O

- Sensors produce a signal in response to a change in their surroundings
  - e.g. thermostat
- Actuators produce a physical change in their surroundings in response to a signal
  - e.g. motor

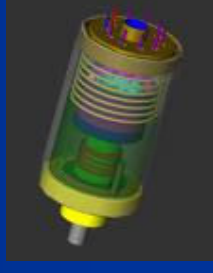
# Light

- Sensing Light
  - Light Sensors (photodiode, color sensor, IR and UV-sensors, etc.)
  - Supply information on the light intensity, density, reflection, color temperature and type of light.
  - Vary in their sensitivity for a specific wavelength or for a specific spectrum.
- Making Light
  - LED's
  - LCD's displays
  - LCD projector



# Movement, Motion and Orientation

- **Accelerometers**
  - provide rich information on the inclination, motion, or acceleration of an object.
  - Typical sensors are mercury switches, angular sensors, and accelerometers.
- **Passive IR Sensors (Motion Detector)**
  - respond to changes in the infrared light in the space. Have a directed input (usually an angle between 30° and 180°)
  - Useful for static objects
- **Magnetic Field**
  - offers information similar to a compass, so the direction of a device or movement can be determined.
  - Measure the orientation of an object.
- **Potentiometer**
  - The simplest rotation sensor



# Making Movement

- DC Motor
  - Very fast, spins at several thousand RPM.
  - Motor direction can be reversed (by switching polarity).
- Stepper motors
  - Does not turn continuously, but in a series of steps.
- Servo Motors
  - Go to a given position for a given length of pulse



# Sound

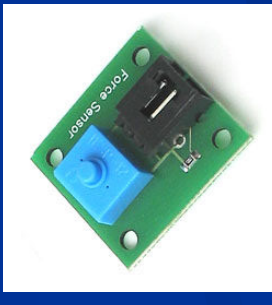
- Sensing Sound
  - Microphones for human hearable audio
  - Special sensors for ultrasonic
  - Get basic information such as noise, sound level, type of input (noisy, music, speaking), base frequency (requires simple calculations)
  - Complex audio analysis by speech recognition (requires more processing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





# Touch and Proximity

- Force Sensor
  - Resists to different degrees depend on how hard it is being pressed.
- Capacitive touch sensor
  - Detects a touch through plastic, glass, paper.
- Beam Switches
  - When the beam is broken by a body passing between the sensor and the light source, the switch is activated.
- Magnetic Switches
  - A thin pair of contacts in a protective housing. When exposed to a magnet, they're drawn together, closing the switch.



# RFID Based Systems

- Electronic identity code within a single chip, read by a near electro-magnetic field
  - Cheap, robust, secured by crypto algorithms
  - No line of sight needed
  - Collision detection / multiple readings possible

Various frequencies: 125Khz— 2.4 GHz

- Uniquely identify objects or persons
- Store data (small amount)

# RFID Tags

- Active (tag includes battery powered radio)
- Passive (tag is supplied during the reading process with energy, no battery)
- Identifiers (read-only)
- Memory (read-write)
- Can be use on or within objects (subjects)
- Reading range: ca. 2cm to 3m (passive tags)



# RFID Readers

- **Communicate with the RFID tags**
- **Reader component and antenna**
  - integrated in buildings (e.g. locks)
  - mobile devices (standalone or add-ons)
  - devices connected to PCs embedded into objects
- **Connection to the host device**
  - Serial line, USB
- **Antenna**
  - Integrated
  - Panels
  - Gates
  - Custom



A. Seimdt, C. Decker, Mechatronik & Computer 2003, Stuttgart

# Summary - choosing the right technology

Sensing technology	Interaction events	Physical relations	Physical output
RFID	Add, remove	Identity, presence (multiplicity).	Identity (write)
Computer vision	Add, remove, move (gestures)	Identity, presence, position, spatial relations (near, above, etc), containment, order, physical properties (color, texture).	
Microcontroller - sensors and actuators	Add, remove, move, property change, rotate	Identity (by property), order (by property) presence, containment, proximity, touch, physical properties (temperature, weight, .humidity, etc.).	Motion (motor), sound, light, temperature.

# Additional resources

- <http://stage.itp.nyu.edu/~dano/physical/>