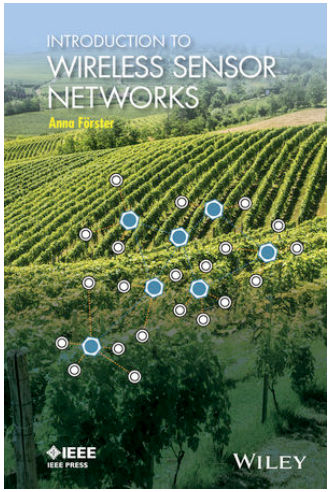


INTRODUCTION TO WIRELESS SENSOR NETWORKS

CHAPTER 9: SENSING TECHNIQUES

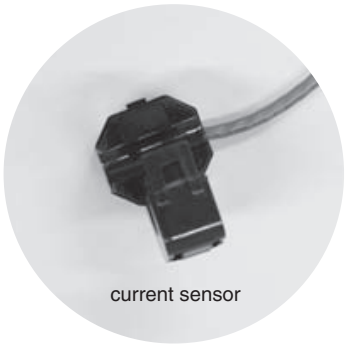
Anna Förster

OVERVIEW

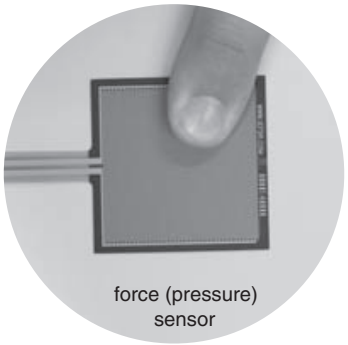
1. Types of Sensors
2. Sensing Coverage
3. High-Level Sensors
4. The Human as a Sensor
5. Actuators
6. Sensor Calibration
7. Detecting Errors

Types of Sensors

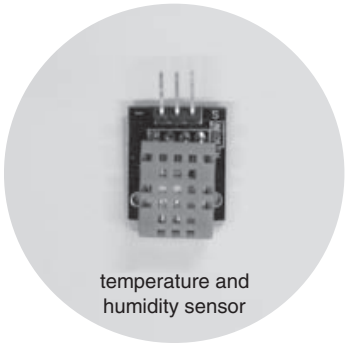
- Passive against active sensors
- Omnidirectional against narrow-beam sensors

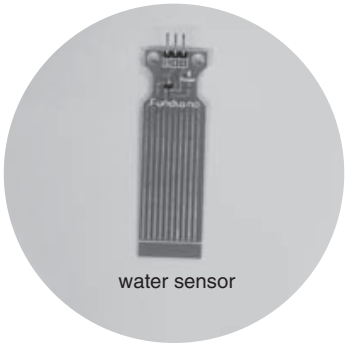

current sensor


distance sensor


force (pressure) sensor


gas sensor


temperature and humidity sensor


water sensor

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Sensing Coverage

- Sensing coverage: maximum distance at which the sensor can still sense correctly the phenomenon
- Sensing model: what happens if the distance is exceeded?
  - **Binary sensing model**: the sensor works perfectly inside its sensing distance and not at all outside.
  - **Power law sensing model**: the the sensor's reliability decreases with increasing distance from the phenomenon.

High-Level Sensors

- Also called software sensors
- Combination of several sensors via sensor fusion

Sensor	Input						
Door code entered	Yes	No	No	No	No	No	No
Movement	n/a	No	No	No	Yes	Yes	Yes
Door open	n/a	No	Yes	n/a	No	Yes	n/a
Window open	n/a	No	n/a	Yes	No	n/a	Yes
House intrusion	No	No	Yes	Yes	No	Yes	Yes

- Special Case: Human as a sensor.
  Example: Restaurant ratings, danger situations, etc.

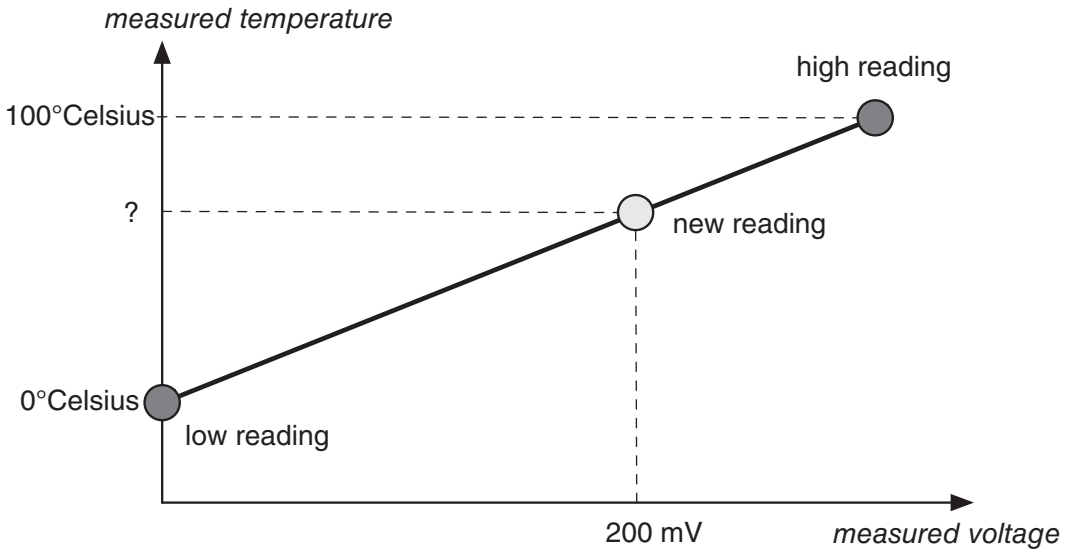
Actuators

- Closes the loop: sense – process – act
- Motors, alarms, irrigation pumps, etc.

Sensor	Input						
Door code entered	Yes	No	No	No	No	No	No
Movement	n/a	No	No	No	Yes	Yes	Yes
Door open	n/a	No	Yes	n/a	No	Yes	n/a
Window open	n/a	No	n/a	Yes	No	n/a	Yes
House intrusion	No	No	Yes	Yes	No	Yes	Yes
Loud alarm	Off	Off	On	On	Off	On	On
Silent alarm	Off	Off	On	On	On	On	On

Sensor Calibration

- Critical step before or while using a sensor
- Makes sure that the delivered data is correct
- Compares the sensor on hand with another, already calibrated one (or physical one, which does not need calibration)



Detecting Errors

- Offline Error Detection: similar to calibration, test the sensor with various inputs
- Online Error Detection: try to detect errors during normal work.
  - Main problem: if the sensor data changes, is it the phenomenon that changed or is the sensor faulty?
  - Solution 1: use several sensors and compare their readings
  - Solution 2: observe the battery voltage (recall Chapter 2)

Sensing: Summary

- Sensors build the most important part of sensor networks.
- Different types of sensors exist such as **active** and **passive** sensors, **omnidirectional** and **narrow** band sensors. All sensors can be characterized by their:
- **Sensing coverage**, which defines the maximum distance and area at which the sensor works reliably.
- **Sensing model**, which defines how reliability changes with increasing distance from the sensor.
- In practice, binary sensors are preferred, which work reliably in a predefined coverage area and do not work reliably outside of it.
- The process of matching the output of a sensor to some physical entity (such as temperature in degree Celsius) is called **calibration**. Sensors need to be calibrated periodically to ensure that they still deliver correct results.
- **Sensor errors** can be detected offline (before deployment) in the process of calibration or online (during deployment). The second is challenging due to changing sensor readings, which can come from changes in the environment or faulty sensors.