EE-594 **Smart sensors for IoT**

Cursus	Sem.	Type
Data and Internet of Things minor	H	Opt.
Electrical and Electronical Engineering	MA1, MA3	Opt.
Microtechnics	MA1, MA3	Opt.

Language of teaching	English
Credits	3
Session	Winter
Semester	Fall
Exam	Written
Workload	90h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

pas donné en 2024-25

Summary

This lecture provides insights in the design and technologies of Internet-of-Things sensor nodes, with focus on low power technologies. The lectures alternate every two weeks between sensing technologies of various kinds (prof. Ionescu) and their integrated circuit readouts (prof. Enz).

Content

Part I (A.M. Ionescu) â## 14 hours (2 x 7) â## Energy efficient IoT sensors and technologies

1. Introduction: wearable technology and energy efficient autonomous smart systems
2. Low power sensor technology
   - Motion sensors: accelerometers, magnetometers, gyroscopes (MEMS solutions)
   - Biosignals and biosensors: ECG, EEG, EMG, EO, blood pressure, pulse wave velocity, SpO2, pH, ions (Na+, K+, Ca2+), glucose, cortisol
   - Gas and particle sensors for air quality and breath analysis
   - Temperature sensors
   - Emerging 2D and 1D nanomaterials for sensing

3. Energy efficient computing technologies for wearable applications:
   - Low power CMOS
   - Flexible electronics

4. Heterogeneous integration: roadmaps and trends for wearables
   - Systemsâ##onâ##flex: substrates and integration techniques
   - 3D heterogeneous integration

5. Wearable energy harvesting technology:
   - Energy harvesting from motion
   - Energy harvesting from thermal gradients: thermoâ##electricalâ##generators (TEGs)
   - Energy harvesting from light in indoor and outdoor conditions
   - Energy storage and power management: superâ##caps and thin film batteries.

6. Contextâ##driven embodiments of wearable systems and related applications
   - Smart patches and stamps â## stateâ##ofâ##theâ##art, promises, challenges

- Smart garments â## stateâ##ofâ##theâ## art, promises, challenges
- Smart watches, smart glasses: Apple, Google, Samsung versus others

Part II (C. Enz) â## 14 hours (2 x 7) - Electronic sensor interface for the IoT
7. Introduction to the IoT.
8. Description and modeling of the most important sensors that are appropriate to the IoT from an energy consumption and noise perspective.
9. General structure of an electronic sensor interface, including front-end electronics, signal conditioning and analog-to-digital converter (ADC).
10. Basic front-end circuits for interfacing IoT sensors including their power and noise optimization.
11. Low-power and low-noise signal condition circuits (amplifiers, filters, sample-and-hold).
12. Low-power ADCs.
13. Examples of sensor interface electronics.

Keywords

Internet-of-Things hardware, wireless sensors, innertial sensors, gas and exposome sensors, biosensors, wearable sensors, energy harvesting, integrated circuit design for sensor readouts, signal-to-noise ratio, noise in analog electronic circuits.

Learning Prerequisites

Required courses

No pre-requisite is mandatory.
Having basic knowledge and have taken lectures in semiconductor devices and analog IC design would facilitate the understading.

Important concepts to start the course

Internet of Things and Edge Artifical Intelligence.

Learning Outcomes

- IoT sensor technologies
- sensing concepts
- sensor main figures of merit
- IC readouts for IoT sensors

Teaching methods

1- oral lectures
2- exercices based on selected applications for IoT sensor and readout design

Expected student activities

- read in advance the lectures corresponding to the sessions of exercices.
- no particular homework scheduled

Assessment methods

Written final exam, no mid-term exam.

Resources

Moodle Link

- https://go.epfl.ch/EE-594