UCLouvain

lelec2102

2021

Project in Electrical Engineering: Integration of wireless embedded sensing systems

5.00 credits	22.5 h + 22.5 h	Q1

Teacher(s)	Bol David (coordinator) ;Jacques Laurent ;Louveaux Jérôme ;Standaert François-Xavier ;
Language :	English
Place of the course	Louvain-la-Neuve
Main themes	In information and communication technologies (ICTs), embedded systems are computing systems that interact with the physical world with a dedicated function. They fill up our industrial world: from cash machines to consumer connected objects and IoT devices to automotive regulation systems to production-line control systems to medical equipment. This integrated project deals with wireless embedded sensing systems and their core technologies from both the disciplines of the Master degree in electrical engineering (electronic circuits and systems, communication systems, information and signal processing, cryptography, electronic materials and devices, and energy) and from embedded software programming. We will specifically practice the multi-objective optimization of these embedded systems with respect to sensing performance, communication range, robustness, power consumption and resource usage. Within the social-ecological transition, an important point is to use technologies like ICTs for meaningful applications with positive societal and/or environmental outcomes. In this project, we will focus on an audio monitoring system for natural ecosystem preservation.
Learning outcomes	**At the end of this learning unit, the student is able to :** a. Contribution of the activity to the learning outcomes of the program In view of the LO reference framework of the "Master in Electrical Engineering", this course contributes to the development, acquisition and evaluation of the following learning outcomes: • LO1.1, 1.2 and 1.3 • LO2.1, 2.2, 2.3, 2.4 and 2.5 • LO4.1, 4.2, 4.3 and 4.4 • LO5.1, 5.4 and 5.6 • LO6.1 b. Learning outcomes **After this course, the students in electrical engineering should be able to:** . • Evaluate the requirements (e.g. detection level, datarate, communication range, security, power budget, …) of a wireless embedded sensing system in a given applicative context from the characteristics of the signals to be sensed • Characterize experimentally the multi-objective performance of a wireless embedded sensing system : communication performance (e.g. range, sensitivity, blocker tolerance), sensing performance (e.g. limit of detection), security, resource usage (memory footprint, power consumption, bill of material, spectrum bandwidth). • Program a microcontroller with limited resources (memory, computing performance, power budget) to acquire sensor data, perform simple processing and transfer them wirelessly • Program an MPSoC to implement a DSP algorithm • Deploy a wireless communication system according to PHY- and MAC-level specifications • Tune a simple event detection algorithm for a given dataset Select a simple encryption and authentication protocol for wireless data transfer
Evaluation methods	In this course, the students are evaluated through: • a certificative group evaluation, based on short summaries of group work sessions delivered during the semester, this cintinuous evaluation accounts for 20% of the final grade for the summaries altogether, each summary being evaluated in a binary manner; • a certificative written group evaluation, based on a project report at the end of the semester, which accounts for 50% of the final grade; • an individual oral exam during the exam session, which accounts for 30% of the final grade.

Teaching methods	The teaching method is based on a few lectures to introduce the scope of the project and the basic notions of the central technologies involved followed by hands-on sessions to practice the concepts on the project development framework and provided hardware equipment. A significant part of the work consists in the project realization in groups, with regular consultancy sessions with the teaching team.
Content	• Embedded systems: bare metal and OS-based programming in C/C++ and/or higher-level language, inputs/outputs and hardware abstraction layer (HAL), timing and sequencing, memory management, implementation of DSP algorithms. • Wireless communications: digital modulation schemes, synchronization, simple medium-access control techniques, baseband processing. • Digital electronic systems: microcontroller and FPGA-based embedded system architecture and operation, power management, fixed-point arithmetic, hardware acceleration on FPGA. • Audio signal processing: sampling and quantization effects, denoising, spectro-temporal feature extraction and basic statistical/machine-learning classification methods. • Data security / cryptography: private-key encryption and authentication.
Inline resources	https://moodle.uclouvain.be/course/view.php?id=4829
Faculty or entity in charge	ELEC

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Electrical Engineering	ELEC2M	5		