2SC7290 – Smart cities: connected cities

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Department: DOMINANTE - SYSTÈMES COMMUNICANTS ET OBJETS CONNECTÉS
Language of instruction: ANGLAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 80
On-site hours (HPE): 48,00

Description
The projects are centered around practical applications of optimization (combinatorial, convex) and game theory to the current problems of smart cities. The projects will be multidisciplinary and will serve to put into perspective the courses of ST7 and to introduce students to engineering problems and/or scientific research in the field. Examples of projects: gathering and routing of data in smart cities, route optimization for cycling, optimisation strategies for charging bikes at station, electrical consumed energy forecasting, etc.

Quarter number
ST7

Prerequisites (in terms of CS courses)
Communication networks (basics), optimization, Matlab

Syllabus
Examples of projects: gathering and routing of data in smart cities, route optimization for cycling, optimisation strategies for charging bikes at station, electrical consumed energy forecasting, etc.
The practical context of the project is related to a precise service in smart cities (information gathering from sensors, temperature regulation, video surveillance, consumption of electric energy, route optimization for cycling, etc.) and it will be given as a complement to the courses. Students will propose and implement convex optimization or game theory algorithms seen in the courses. They will then test their approaches on potentially in real data.

Class components (lecture, labs, etc.)
Each project is assigned on average to five students and is mainly supervised by a professor. Some projects are jointly proposed with some industrial partners and are hence co-supervised by engineers from these companies. A room dedicated to the projects will be available to students. The supervisors will follow up regularly (one meeting / group / week at the

beginning and one daily meeting per group during the final week). Inter group collaboration will be encouraged (whenever it is possible), and students will be assessed on their ability to work in teams (leadership, tasks' sharing, communication).

Grading
report to write+defense (per group)

Resources
software to use: Matlab

Learning outcomes covered on the course
At the end of the project the student will be able to:

1- know emerging problems in smart cities (telecommunication networks, routing of data, smart charging, etc.)
2- model a network in the context of smart cities with its main functions
3- formulate emerging problems in smart cities as optimization frameworks
4-implement convex optimization and game theory methods in Matlab

Description of the skills acquired at the end of the course
C1 : Analyse, design and implement complex systems made up of scientific, technological, social and economic dimensions.
C1.1 : Examine problems in their entirety and beyond their immediate parameters. Identify, formulate and analyse the scientific, economic and human dimensions of a problem
C1.2 : Develop and use appropriate models, choosing the correct modelling scale and simplifying assumptions when addressing a problem
C1.3 : Apply problem-solving through approximation, simulation and experimentation. / Solve problems using approximation, simulation and experimentation
C1.4 : Design, detail and corroborate a whole or part of a complex system.
C1.5 : Bring together broad scientific and technical concepts in a core structure contained within the framework of an interdisciplinary approach.
C2 : Acquire and develop broad skills in a scientific or academic field and applied professional areas
C2.1: Thoroughly master a domain or discipline based on the fundamental sciences or the engineering sciences.
C2.3 : Rapidly identify and acquire the new knowledge and skills necessary in applicable / relevant domains, be they technical, economic or others.
C3 : Act, engage, innovate within a scientific and technological environment
C3.1 : Be proactive and involved, take initiatives
C3.2 : Question assumptions and givens. Overcome failure. Take decisions

C6 : Thrive in an international and multicultural environment
C6.1 : Identify and use the necessary software for one's work (including collaborative tools) and adapt digital responses according to the context.
C8 : Lead a team, manage a project
C8.1: Work collaboratively in a team.
C8.2 : Train and motivate a group, demonstrating effective leadership.
C8.4 : Work using project management techniques appropriately tailored to the situation.
C9 : Think and act as an accountable ethical professional
C9.2, : Identify, within a given structure, the scope of liability as well as socio-ethical and environmental responsibilities.
C9.4 : Demonstrate rigour and critical thinking in approaching problems from all angles, be they scientific, social or economic.

ST7 – 73 – CIRCULAR ECONOMY AND INDUSTRIAL SYSTEMS

Dominante : GSI (Large Interacting Systems), VSE (Living-Health-Environment), CVT (Construction, City and Transport)
Langue d'enseignement : French
Campus où le cours est proposé : Paris-Saclay

Engineering problem

Companies are becoming actors in the transition to a more environmentally friendly economy. For example, several of them called for a strong agreement at COP21 and since then more and more of them are deciding to act and transform their practices towards more "circular" models. This new way of doing business translates into action several mutually reinforcing factors: the growing awareness of the challenges of the ecological and energy transition, the multiplication of initiatives on a territorial scale, the strengthening of laws and standards towards a more sustainable economy, and market balances that are changing and making sustainable practices more profitable.

The circular economy aims to move away from a culture of extraction and waste and to optimize the use of resources to minimize the impact of human activities on the environment. Industrial ecology is a scientific approach to integrated metabolism that makes it possible to implement this circular economy, via - among other things - industrial synergies (pooling of material, water or energy flows between companies), the eco-design of products and services, or the economy of functionality.

It is a formidable field of innovation, commercial differentiation and a sustainable and profitable growth relay that is emerging. This circular economy needs leaders capable of understanding the issues at stake, trained to initiate and manage ambitious projects at the level of companies and territories.

This Engineering Challenge Term (*Séquence Thématique*) tackles in detail Circular Economy through engineering strategies, methods and tools that allow its implementation (thus this is not an economy course). It alternates between theory (course), application (tutorial classes, academic project, industrial project), and activities by industrial or institutional partners (conferences, workshops, industrial project).

Advised prerequisites

None

Context and issue modules: The introduction of the sequence is organized around three half-days aiming at presenting the sequence, the projects and introducing the issues of the Circular Economy, with the following activities:

Introductory conferences and round table: introduction to Circular Economy by field actors (National Institute of Circular Economy, Law firm specialized in Circular Economy)

Discovery workshops: workshop "Impacts of the Smartphone" (example of the Fairphone), workshop "Circular business models" (example of the SEB company), workshop "Reuse and repair strategies" (example of recycling centers)

If possible, site visits (e.g. Paris-Saclay heating and cooling network), or industrial conferences.

Specific course (60 HEE) : *Circular Economy and Industrial Ecology Methods*

Brief description: The course aims to go through the different dimensions of the Circular Economy to give students an overview of the field. Then the focus will be on the operational tools of Industrial Ecology that students will learn to manipulate (MFA and LCA software) to carry out an "academic" Industrial Ecology project by modeling material and energy flows and by measuring environmental impacts. These tools can be used in the industrial project of the thematic sequence.

Projects:

The sequence is built around an industrial project; 2 to 4 topics in connection with industrial partners will be proposed to students, including at least one project carried by the VSE major and one by the CVT major. The topics described below are those of past years and are provided for information purposes only. Those of 2022 will be on similar topics.

Project #1 (example 2020 to 2022) : *Biorefinery : optimization of flows and/or associated processes*

- Industrial Partner : Chair of Biotechnology, ARD

- Location : Paris-Saclay + visit of the biorefinery of Pomacle (CEBB and partner industrial site)

- Short description : The biorefinery can be defined as an industrial ecosystem that transforms biomass (agro resources and animal waste) into several products from alimentary to energy, chemicals, raw materials, cosmetics,

health…). France is a leading country in this field at the international level, thanks to the biorefinery located in Pomacle Bazancourt, which treats more than 4 Mt of biomass per year. The biorefinery is, therefore, a relevant industrial tool to accompany the ecological transition, first to answer the issue of climate change and second to help the industrial relocation, especially in territories of agricultural and forestry production. The biorefinery also contributes actively to Sustainable Development (environment, economy, and social pillars). The project aims to map the different production units and characterize and quantify the inputs and outputs streams. Second, from this exploration phase, the goal is to propose new stream exchange architecture to optimize the environmental footprint of the biorefinery. The proposed approach is multidisciplinary and mixes data science, modeling-simulationoptimization, process engineering, and industrial engineering. The students are expected to work in a group to identify, develop and present operational solutions that reduce the environmental impact of the biorefinery.

Project #2 (example 2021) : *ESA_Lab@CentraleSupélec*

- Industrial Partner : Agence Spatiale Européenne (ESA)

- Location : Campus Paris-Saclay

- Short description : the MELiSSA project of ESA aims at developing a regenerative support life system to reproduce the main function of the Earth ecosystem (water and oxygen production), in a limited mass and volume and with an exterme security. MELiSSA is on of the most accomplished Circular Economy example in the world, considering loops of material and energy flows. ESA_Lab@CentraleSupélec, created in 2020, is a privileged collaboration framework between ESA and CentraleSupélec. Its objective is to develop the interest and knowledge of peaceful space exploration activities, and associated transverse applications, like climate observation, Earth observation, navigation, (cyber)security, artificial intelligence, sustainability, spatial economy..., to the mutual benefit of the two organizations and the Society. This ST7 projects aims at specifying and proposing first scenarios of the preliminary design of a future "demonstration lab", that will be a place of scientific experiments and projects around Circular Economy and with close links with MELiSSA. The project is structured in two main phases: (1) Specification of the demonstration lab: needs and first ideas identification, thanks to a literature review and interviews with CentraleSupélec stakeholders and ESA experts; (2) Preliminary design of the demonstration lab.

Project #3 (example 2022) : *Laptop reconditioning*

- Industrial Partner : Emmaüs Connect

- Location : Campus Paris-Saclay + visit of a laptop reconditioning center

- Short description : Member of Mouvement Emmaüs, Emmaüs Connect is a French association created in 2013 to fight digital divide and digital illiteracy. Emmaüs Connect launched in November 2020 LaCollecte.tech, a platform that allows organizations to provide a second life to their unused digital devices to the benefit of people in social and digital insecurity. The project aims at fostering laptop reconditionning for the 8 million of French citizens who do not have access to the internet and thus to first need services (while in the meantime, 33% of companies own dormant devices they are not able to value). Four axes were studied (each group of students handled two of them): (1) imagine a "universal" shell that would allow to recreate a new second hand laptop with any resued component; (2) design a tool to assess the compatibility of laptop components from different brands, different models and based on available stocks; (3) study the feasibility of a laptop whose motherboard would be a Raspberry Pi (because laptop's motherboards are very hard to reuse as components are very often welded); (4) propose advocacy measures for laptop manufacturers to promote the evolution of their industrial practices towards more circularity and sustainability.

Project #4 (example 2022) : *Circolab student trophy*

- Industrial Partner : association professionnelle Circolab

- Location : Campus Paris-Saclay + visit of the building site of the olympic village (Saint-Denis

- Short description : Circolab is a professional association of organizations from the real estate and building sector aiming at promoting circular economy in their activities. Circolab launched in 2022 the very first edition of the Circular Economy Trophy intended for engineering and architecture students, including CentraleSupélec. Several case studies were proposed to students with a common objective: propose realistic and quantified circular economy initiatives at the scale of a building or a city district. The ST7 students worked on two case studies associated with the futur athletes' village for the Olympic Games in Paris in 2024: (1) A case proposed by SOLIDEO (organization in charge of the construction of olympic works) at the scale of a city block to imagine solutions for circularizing water flows; (2) A case proposed by Vinci at the scale of another city block to imagine solutions to maximize the valorization of equipments (partition walls, furniture, bathrooms) between the phase "Games" (= during the games) and the phase "Legacy" (= after the games, when the village will become a housing, offices and shops district).