2SC8193 – Optimization of civil engineering structures in additive concrete manufacturing

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Department: DOMINANTE - CONSTRUCTION VILLE TRANSPORTS
Language of instruction: ANGLAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 80
On-site hours (HPE): 48,00

Description

Project to answer a problem proposed by a partner of the civil engineering industry around the optimization of the design of a part in additive manufacturing concrete or plaster.

Quarter number

ST7

Prerequisites (in terms of CS courses)

To have completed the "continuum mechanic" SPI course and at least one of the following courses: Materials, Transport phenomena, Thermodynamic.

Syllabus

Students are divided into teams of up to 5. Each team must optimize the design of a large civil engineering part subjected to complex mechanical and even multiphysical loads. This may involve optimize its geometry, to think about its design, to design a system for a given use system for a given use, analyze the performance of a part already designed by already designed by additive manufacturing... This work must take into account the This work must take into account the specific capabilities and restrictions of the concrete or plaster additive manufacturing process.

step 1: Getting to know the subject
step 2 : Simplified representation of the studied part to reach a first optimum
first optimum on a first field of parameters.
step 3 : Optimization of the system in a new space of parameters closer to the real system modeled by advanced methods.

step 4 : Analysis of the cost benefits of the proposed solution compared to the usual solution e.g. manufacturing time, cost of materials, manpower used, environmental compatibility...

Most topics involve finite element simulation on COMSOL or the software of the students' choice. Some topics may involve Some topics may involve experimentation.

Grading

C2 and C8 skills will be evaluated throughout the project, which will end with a defense in the presence of the industrial partner. Competencies C2 and C7 will be evaluated during the defense. The partner will evaluate the C4 competence.
Continuous assessment during the project (C2, C8) : N1
Teachers' grade for the oral defense (C2, C7) : N2
Industrial partners' mark for the oral defense (C2, C4, C7) : N3
NF = 30%N1 +30%N2 + 40%N3

Description of the skills acquired at the end of the course

C2 Develop in-depth skills in an engineering field and a family of professions
C4 Have a sense of value creation for his company and his customers
C7 Know how to convince
C8 Lead a project, a team

ST7 – 82 – PHYSICAL NEURO-INSPIRATORY SYSTEMS FOR INFORMATION PROCESSING

Dominante : PNT (Physics and NanoTechnology)
Langue d'enseignement : English
Campus où le cours est proposé : Metz

Engineering problem

In a context of constant increase of the volume of information to be processed, it is necessary to define new analysis strategies. Automatic classification methods based on machine learning are promising, but their numerical implementations remain slow and very energy-consuming. An alternative solution consists in designing hardware architectures called neuro-inspired, which allow to lift a large part of these barriers. This theme is attracting growing interest both in fundamental research and among start-ups and large high-tech groups such as IBM and Google.

In this context, and through a specific architecture known as the reservoir computer (an artificial neural network for which only a final reading layer is trained), we propose to students to discover the design principles of physical neural networks. For this, students will use many optimization techniques such as ridge regression and gradient descent, as well as their accelerated versions, or stochastic heuristics (e.g. simulated annealing, genetic algorithms).

The objective will be to simulate and test a prototype of a physical neuro-inspired processing architecture comprising several tens, even hundreds of thousands of neurons and to demonstrate its low energy consumption, to determine the equivalent number of floating operations per second achievable compared to a computer on classification tasks.

Advised prerequisites

Knowledge of equations and dynamical systems. Courses in statistics, signal processing and automation, good command of a programming language (e.g. Matlab, Python, or C/C++).

Context and issue modules: These modules include an introductory conference on the theme by personalities from the academic and industrial worlds, presentations on the technological and scientific obstacles, and a presentation of the associated projects.

Specific course (60 HEE) : *Optimization for learning physical systems*

Short description: This course presents the physical and mathematical tools for the realization and training of artificial neural networks: echo state network (ESN), electronic and photonic implementations, memory and computational capacity of physical architectures, supervised and unsupervised learning, ridge regression and regularization, accelerated gradient descent techniques, heuristic methods, hardware approaches for deep networks, emerging technologies (e.g. integrated photonics, nano-photonics and spintronics)

Project: *High performance and low energy cost classification of video signals and images by photonic systems*

- Associated partners: Start-up Light On, CentraleSupélec / Photonics Chair and FEMTO-ST Institute

- Location: Metz campus

- Short description : The project will focus on the learning/optimization of an experimental photonic architecture of a neuro-inspired analog computer (developed in CentraleSupélec laboratories in collaboration with the FEMTO-ST Institute). Students will have to choose learning/optimization strategies from the course and implement them so that the photonic architecture can perform image/video signal classification or solve industrially oriented problems proposed by our industrial partner Light-On. The organization of the project is as follows:

1) Rapid bibliographical study of the image or video signal classification task (or task proposed by the Light-On partner)

2) Numerical simulation on a realistic model of the architecture (provided) under Matlab. Implementation of learning methods based on linear/ridge regression, multi-logistic regression, or stochastic heuristics (unknown cost function model).

3) Identification of important physical hyper-parameters (experimentally adjustable) for the photonic architecture

4) Experimental tests, performance analysis, evaluation of the computational capacity (flops) and comparative study of the energy performance (energy cost per processed image/video sequence) compared to software methods.