2SC8290 – Classification of image and videos signals with power-efficient photonic systems

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Department: DOMINANTE - PHYSIQUE ET NANOTECHNOLOGIES
Language of instruction:
Campus: CAMPUS DE METZ
Workload (HEE): 80
On-site hours (HPE): 48,00

Description

This project is part of the thematic sequence ST7 "Physical Neuro-inspired Systems" and is about the automatic classification of image / video signals using photonic architectures developed within The CentraleSupelec Research Center. There are many applications to classification of images or video sequences such as assistance of diagnosis in healthcare, autonomous robotics, or scene analysis for defence and security.

Various software-based techniques exist to solve classifcation tasks and they run on central processing units (CPU) or graphical processing units (GPU). The downside is usually reduced processing speed and high power consumption during learning and testing phase. These are strong motivations for the development of alternative hardware (physical)-based architectures using analog electronics or photonics.

The objective of this project will be : (i) the study of the ability of a photonic architecture to classify video or images from publicly available databases, (ii) the optimization of its performance to be competitive with state-of-the-art software solutions and (iii) provide an estimation of the power efficiency of the architecture.

Quarter number
ST7

Prerequisites (in terms of CS courses)
Modeling (1CC3000)
Digital Signal Processing (1CC4000)
Statistics and Machine Learning (1CC5000)

Syllabus

1. Numerical simulation of a large-scale neuro-inspired photonic architecture (>10,000 interconnected dynamical systems)

- Choice of software language : *e.g.* Matlab / Python or C/C++
- Use of different learning strategies : (i) offline (*e.g.* linear and ridge regression, stochastic heuristics) or (ii) online (e.g. gradient descent and their accelerated versions).
- Search of optimal operating points with parametric exploration

2. Handling of a publicaly available database of video or image signals

- Choice and analysis of pre-processing algorithm for "features" extraction suitable for classification tasks.
- Techniques for the dimensionality reduction of the "features"

3. Experiment on prototype architecture

- Implementation of the chosen learning technique on the physical setup. (experimental settings and tuning done by the teaching staff)
- Experimental campaign

4. Performance analysis

- Performance (error / success rate in classification) and comparison with the state of the art (bibliographic search)
- Estimation of the power consumption for the resolution of a task (including the energy consumption during the training and energy use per signal processed)

Class components (lecture, labs, etc.)

This class is a small project with the following requirements :

- team-work (3 à 4 students) for 80 HEE (*i.e.* 48 HPE).
- organization of periodic meeting with teaching staff to monitor overall progress on the project, the code development, and for discussing the numerical and experimental results obtained.
- Writing one mid-term report (approx. 5 pages) on overall progress and including some technical details and a final report (approx. 10 to 15 pages) for the last week of the class.
- Two oral defenses : one mid-term defense (S1) only with the teaching staff and a final defense (S2) at the end of the project with the participation of industrial and academic partners.

Grading

The evaluation process is as follows :

- Continuing evaluation (CC) on project management (including but not limited to regular scheduling of meetings, progress, technical mastery of the topic...). Group and invidual performance will be taken into account and weighted equally.
- Two oral defenses (S1 et S2) Group and invidual performance will be taken into account and weighted equally.
- Technical content and quality of written material (L) (reports, bibliographic archives, commented source codes...).

Final grade = CC / 3 + (S1+S2)/6 + L/3

Resources

- Teaching staff : Damien Rontani, Piotr Antonik
- Desktop computers from the LMOPS laboratory of Metz Campus and the FUSION Super Compyter (Paris-Saclay) available for intensitve numerical simulations and parametric analysis.
- Personal computer of students
- Remote access to an experimental setup for testing on a prototype architecture developed within the LMOPS laboratory on Metz Campus

Learning outcomes covered on the course

By the end of the this project, the students will be able to

- Numerically simulate a large-scale dynamical system with Matlab / Python or C/C++ and apply offline and online learning techniques for the learning of physical architectures
- Analyze operating points and parametric mapping of performance of physical systems
- Use and apply pre-processing to publicly available database of image / video signals
- Experiment on prototype of photonic neuro-inspired architectures

Description of the skills acquired at the end of the course

C4 Have a sense of value creation for one's company and one's client
C7 know how to convince
C8 Lead a project, a team

INTENSIVE COURSES