

– Thesis Offer –

## Frugal and Robust Incremental Learning

**Advisors:** Olivier Alata (Professor) and Jordan Frecon-Deloire (Associate Professor)

**Host laboratory:** Hubert Curien Lab UMR CNRS 5516, Saint-Etienne, France

**Application deadline:** May 1st, 2023

**Keywords:** Incremental learning; Deep learning; Frugal AI; Action recognition; Geometrical transformation invariance; Real conditions; Robustness.

**Context** The present thesis proposal is part of the *GreenAI research project* resulting from the collaboration between academic (Hubert Curien Lab) and industrial partners (Asygn, DRACULA Technologies, STMicroelectronics). Its main objective is to create autonomous smart sensors benefiting from a low ecological footprint for road monitoring purposes. As such, this project is inherently a vector of cross-cutting developments in microelectronics, machine learning and embedded systems design.

**Description** This subject aims at developing incremental learning algorithms for action recognition, with an emphasis on robustness and frugality. Incremental learning is a category of machine learning allowing to update the parameters of the decision model as the data is acquired. This type of approach proves particularly relevant in order to dynamically adapt the model to patterns not encountered in the data. With regard to the application studied, these patterns may correspond to new scenes or unexpected actions [1, 2], e.g. a dangerous act for a pedestrian for a road monitoring use case. The developments will focus on three complementary aspects: theoretical guarantees, algorithmic considerations and implementation for experimental validation. A particular attention will be paid to the memory and energy footprint of the techniques, as well as their robustness to different variations in the data and in the acquisition devices.

- *Development of frugal incremental learning algorithms.* Methodological developments will have to respond to two specificities. First, the relatively low proportion of unexpected actions as well as their diverse nature complicates their identification. It will then be necessary to take into account, in an online and adaptive manner, the unbalanced and heterogeneous nature of the data within a machine learning framework. Second, in the perspective of a more frugal AI, we will study how to adapt this class of incremental algorithms for sparse models [3].
- *Invariance and robustness of incremental algorithms.* The same actions in the scenes can be seen from different perspectives, hence modifying the angles and changing the scales of the captured images. It will therefore be necessary to develop a decision model invariant to

certain transformation groups, e.g. translations, scaling, rotation, etc. [4]. Departing from these standard transformations, one will also investigate how to devise a model invariant to the physical parameters of the acquisition device, such as the calibration settings. Last but not least, the decision model should also be robust to variations in the data stream due to its ever-evolving environment. Therefore, it should notably perform equally well under different lighting and weather conditions.

## Candidate profile

- Master or Engineer school in computer science, applied mathematics or related.
- Good Python programming skills. PyTorch experience is welcomed.
- Good knowledge of neural networks. Additional knowledge in probabilities, statistics and physical models would also be appreciated.
- High proficiency in English.

**Application** Candidate must send the following documents to both [olivier.alata@univ-st-etienne.fr](mailto:olivier.alata@univ-st-etienne.fr) and [jordan.frecon.deloire@univ-st-etienne.fr](mailto:jordan.frecon.deloire@univ-st-etienne.fr) as soon as possible:

- Cover letter with justification of your skills for the topic
- A complete Curriculum Vitae
- Transcript of your bachelor and master's/Engineer school's grades.
- CEFR level in English (except if university courses were taught in English)
- Any additional document: letter(s) of recommendation, publications, master thesis, etc.

Please feel free to contact us beforehand for any further pieces of information.

**Funding** The selected candidate will obtain a 36-month funding. The net salary will be around 1700€. Additional paid teaching activities can be envisaged on demand.

**Host laboratory** Created in 2006, the Hubert Curien laboratory is a joint research unit (UMR 5516) of the Jean Monnet University, Saint-Étienne, the National Research Centre "CNRS" and the Institut d'Optique Graduate School. It is composed of about 90 researchers, professors and assistant professors, 20 engineers and administrative staff and 130 PhD and post-PhD students. This makes the Hubert Curien laboratory with a total of about 240 staff the most important research structure of Saint-Étienne.

More information at <https://laboratoirehubertcurien.univ-st-etienne.fr>.

## References

- [1] J. Ma, X. Tao, J. Ma, X. Hong and Y. Gong, "Class Incremental Learning for Video Action Classification", ICIP 2021.
- [2] J. Park, M. Kang and B. Han, "Class-Incremental Learning for Action Recognition in Videos", ICCV 2021.
- [3] M. Barlaud and F. Guyard, "Learning Sparse deep neural networks using efficient structured projections on convex constraints for green AI", ICPR 2020.
- [4] J. Bruna, S. Mallat, "Invariant scattering convolution networks", IEEE TPAMI 2013.