ICT PHD

Research project for a PhD curriculum in ICT – Electronics and Telecommunications

Tutor:
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Proposed Title of the research:
Neuromorphic Computing Hardware for Low-Power Edge-AI

Keywords – (5)
Neuromorphic Computing; Edge Computing; Energy-Efficient Hardware; Pervasive AI; Emerging Non-volatile Memories

Research objectives: – (max 10 rows)
Recently, the explosion of artificial intelligence applications, forecasted to increase exponentially in the near future, raised concerns on the corresponding carbon footprint and related impact on the ongoing climate change processes. Conciliating its mitigation with the disruptive explosion of the digital transformation requires the development of innovative and energy-efficient devices for pervasive and sustainable, low carbon footprint computing architectures. The goal of this PhD thesis, at the border between electronics and neuroscience, is to explore, design, and test new hardware platforms enabling energy-efficient and sustainable neuro-inspired computation, taking inspiration from the mechanisms that subtend the learning processes in the human brain. The specific goal will be the strong reduction of energy consumption for edge AI tasks (inference, prediction, recognition) to strongly decrease the impact of AI technologies on ongoing climate change processes.

Proposed research activity – (max 10 rows)
The research activities will range from the electrical characterization and compact modeling of innovative electro-synaptic devices up to the design of innovative energy-efficient low carbon footprint neuro-synaptic circuits and architectures. Specific targets will be the implementation of new learning strategies onboard the computation platform and the strong reduction of latency and energy consumption for specific edge AI applications (pattern recognition, inference, prediction, behavior anticipation). The research targets will be quantitatively evaluated by assessing the energy efficiency boost achieved by the designed architecture, which will be mapped to the equivalent CO_2 footprint reduction per operation, as required by the needs of the green transition in the context of edge intelligence. The research objectives will be reached by a significant contamination with other scientific domains such as computational neuroscience, that will be fostered by a strong collaboration with fellow neuroscientists from our University.

Supporting research projects (and Department)
The research will be carried out together at the Department of Engineering “Enzo Ferrari” and in collaboration with important partners at the EU level. Specifically, the candidate will spend 6 to 12 months at the premises of NaMLab gGmbH (DE) – a leader enterprise in Europe for research and development of ferroelectric non-volatile memories and neuromorphic computation – to perform research on the technological platforms, devices, and circuits necessary for the development of the target hardware platform.

Possible connections with research groups, companies, universities.
The research may involve collaborations with research groups at:
- NaMLab gGmbH (Germany)
- CEA-Leti (France)
- Applied Materials Italia (Italy)
- King Abdullah University of Science and Technology (Saudi Arabia)