



PhD in INGEGNERIA DELL'INFORMAZIONE / INFORMATION TECHNOLOGY - 39th cycle

Research Area n. 1 - Computer Science and Engineering

**PNRR 117 Research Field: OPTMIZATION OF MACHINE LEARNING AND DEEP LEARNING
ALGORITHMS FOR RESOURCE-CONSTRAINED EMBEDDED SYSTEMS**

Monthly net income of PhDscholarship (max 36 months)

€ 1400.0

In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity

**Motivation and objectives of the research
in this field**

The research has the objective of optimizing the training phase of some Machine Learning and Deep Learning models in order to obtain models whose inference on resource-constrained systems results to be more convenient for what concerns throughput and energy efficiency. In particular, the objective is to optimize the acceleration of the inference of such models on resource-constrained FPGAs. This type of research finds its application in the field of Artificial Intelligence of Things, allowing embedded systems to become not strictly dependent on cloud infrastructures and, thus, to allow the use of powerful Machine Learning models even without an internet connection. Therefore, in order to handle the execution of such models on resource-constrained devices, these systems need ultra-efficient compute nodes. Some of these nodes will be embedded CPU nodes but other nodes will have to be targeted to specific applications and maximally exploit low-level parallelism. Reconfigurability of these hardware nodes is therefore required and, for applications that significantly change their behaviour during their execution, run-time reconfiguration will be an important asset of such hardware nodes. Within this context, the objectives of this research will be the definition of novel hardware nodes exploiting dynamic reconfiguration and the design of the



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| | necessary tools to target these architectures. |
| Methods and techniques that will be developed and used to carry out the research | <p>The research program aims at creating software/hardware systems to provide the ability to perform Machine Learning in real-time. A wide experimental study about several optimizations related to the models needs to be carried out, in order to evaluate the impact of these optimizations on the machine learning model performance and on the compatibility with the employed hardware systems. Some of these components will be embedded CPU nodes but other nodes will have to be targeted to specific applications and maximally exploit low-level parallelism. Reconfigurability of these hardware nodes is therefore required and, for applications that significantly change their behaviour during their execution, run-time reconfiguration will be an important asset of such hardware nodes. Within this context, the objectives of this research will be the definition of novel hardware nodes exploiting dynamic reconfiguration and the design of the necessary tools to target these architectures. This research has as a goal to identify part of the algorithms that would benefit from hardware acceleration on FPGA. Part of the computation will then be offloaded from the CPU to the FPGA, so that the total execution is more efficient.</p> |
| Educational objectives | <p>The student will be required to participate in different activities involving research and teaching, managing and mentoring other students for didactical purposes, and organizing external activities such as the Xilinx PYNQ Hackaton (xph.necst.it). The student will also have the possibility to expand their knowledge about Machine Learning, Deep Learning, and Domain Specific Computing.</p> |
| Job opportunities | <p>Given the renewed interest in FPGA-based systems, different job opportunities can be identified. Just to cite a few companies with which we are collaborating: Technosens S.p.A., Microsoft Research, AMD, Groq.</p> |



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| Composition of the research group | 1 Full Professors 1 Associated Professors 1 Assistant Professors 6 PhD Students |
| Name of the research directors | Prof. Marco Domenico Santambrogio |

| Contacts |
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| marco.santambrogio@polimi.it +393356847022 https://santambrogio.faculty.polimi.it/ |

| Additional support - Financial aid per PhD student per year (gross amount) | |
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| Housing - Foreign Students | -- |
| Housing - Out-of-town residents (more than 80Km out of Milano) | -- |

| Scholarship Increase for a period abroad | |
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| Amount monthly | 700.0 € |
| By number of months | 6 |

| National Operational Program for Research and Innovation | |
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| Company where the candidate will attend the stage (name and brief description) | Tecnosens S.p.A. |
| By number of months at the company | 6 |
| Institution or company where the candidate will spend the period abroad (name and brief description) | AMD (ex Xilinx) |
| By number of months abroad | 6 |

| Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information |
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| <p>EDUCATIONAL ACTIVITIES (purchase of study books and material, including computers, funding for participation in courses, summer schools, workshops and conferences): financial aid per PhD student.</p> <p>TEACHING ASSISTANTSHIP: availability of funding in recognition of supporting teaching activities by the PhD student There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.</p> <p>COMPUTER AVAILABILITY: individual use.</p> <p>DESK AVAILABILITY: individual use.</p> |