Politecnico di Torino

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COMPUTER AND CONTROL ENGINEERING

PNRR - Development framework for the engineering process of edge-based AIoT sensor solutions

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Context of the research activity	An automated system driving a robot must handle many problems simultaneously. For example, the system must locate its position, identify practicable pathways and surrounding objects, determine strategies for interacting with the environment, and prevent accidents. Generally, a System of Systems (SoS) aiming to deal with this variety of issues is composed of a wide variety of modules, each specialized in solving a reduced number of problems. This project will investigate the definition of a framework for the digital design and testing of data fusion algorithms, wherein distributed sensing technologies disseminated in the industrial production lines are integrated through the fog computing paradigm. Progetto finanziato nell'ambito del PNRR M4C2, Investimento 3.1 - Avviso n.3264 del28/12/2021-IR0000011 European Brain ReseArch INfrastructureS - Italy (EBRAINS-Italy) - CUP B51E22000150006
	Research objectives In automation use cases, information extracted by different SoS modules is merged on the path from the raw sensor to the actuator. The pipeline often follows an intuitive order: first, the information from the sensors is processed; then, this information is elaborated by AI-based algorithms; finally, the extracted knowledge is used to elaborate a control strategy for the actuator. The developed framework should support the automatization of each step of the engineering process for creating optimized Artificial Intelligence of Things (AIoT) sensor solutions. Following the key features: 1. Manage onboard sensor data collection and labelling, allowing developers

Objectives	to build datasets from each available sensing system for any given use case. 2. Select and customize AI algorithms for generating efficient inference and data fusion models compatible with on-edge execution. 3. Define optimization strategies and tools for identifying model parameters by exploiting the labelled data acquired by the onboard sensing systems. 4. Validate model accuracy on the target edge device. The framework will be evaluated on selected sensing technologies and analytics tasks involved in relevant industrial use cases in the automation field. In this project, the candidate will target emerging HW technologies such as FPGA, GPU, Neuromorphic platforms, and parallel architectures, to implement new computational paradigms optimizing computation on the edge. Neuromorphic technology will be strongly integrated into the supported use cases. Outline of the research work plan 1st year. The candidate will study state-of-the-art frameworks aimed at designing AIoT solutions to be deployed on the edge. Moreover, the candidate will acquire experience with Neuromorphic HW technologies and embedded systems in the industrial context. He/She will contribute to the definition of the framework requirements, technologies, and solutions for the development of AI applications to be deployed on edge devices. 2nd year. The candidate will develop an integrated methodological approach running on a fog computing platform for modelling applications and systems, accordingly to the experiences obtained during the first year of research in a multi-scenario analysis. He/She will develop the basic structure of a user-friendly framework for supporting the realization of AI applications to be deployed on edge devices. Moreover, it will support the benchmarking procedure. Then, he/she will select software libraries supporting the most promising models identified in the TinyML domain for the specific industrial use cases. For this last point, the candidate will explore models from Imitation, Continuous, Federated, and Deep learning technologies, as well as bio-inspired neuromorphic models. 3rd year. The candidate will apply the proposed approach to different complex systems, enabling greater generalisation of the methodology to different domains. The candidate will define relevant Key Performance Indicators (KPI) for demonstrating the advantages of using the developed framework, compared to the use case's baseline implementation approach. The research activities will be carried out, in collaboration with the Fluently project partners and the EBRAINS-Italy partners. List of possible venues for publications The main outcome of the project will be disseminated in three international conference papers and at least one publication in a journal of the AIoT and neuromorphic fields. Moreover, the candidate will disseminate the major results in the EBRAINS-Italy meetings and events. In the following the possible conference and journal targets: • IEEE/ACM International Conferences (e.g., DAC, DATE, AICAS, NICE, ISLPED, GLSVLSI, PATMOS, ISCAS, VLSI-SoC); • IEEE/ACM Journals (e.g., TCAD, TETC, TVLSI, TCAS-I, TCAS-II, TCOMP), MDPI Journals (e.g., Electronics).

Skills and competencies for the	MS degree in computer engineering, electronics engineering or physics of complex systems. Excellent skills in computer programming, computer architecture, embedded

for the development of the activity	systems, and IoT applications. Technical background in electronic design, modelling, simulation and optimization.