Ph.D. in Information Technology
Thesis Defenses

February 28, 2023
at 9:30
Room Educafe and online by Zoom

Eleonora D'ARNESE – XXXV Cycle

ON HOW TO OPTIMIZE MEDICAL IMAGE ANALYSIS: THE CHIMERA APPROACH

Supervisor: Prof. **Marco Santambrogio**

Abstract:

Digital image analysis, particularly medical image analysis, has become the focus of a considerable number of research studies in industry and academia. Moreover, the constant improvement in the acquisition machinery and digitalization process generates massive data that should be analyzed daily to extract relevant information for the diagnostic process. Indeed, data observation and analysis time are the de facto bottleneck of the clinical practice. Unfortunately, pure human analysis is unfeasible in a reasonable time, given the large amount of healthcare data. Therefore, the introduction of automated workflow for the analysis of such data is becoming of great interest to speed up diagnosis and reduce the workload of physicians. Additionally, given the applicative scenario delivering accurate, fast, and efficient solutions is becoming central.

In this context, this dissertation presents Chimera, an approach for optimizing medical image analysis procedures for pre-processing and processing such images. More specifically, it focuses on two widely employed pre-processing steps: image registration and segmentation.

At the same time, the processing part focuses on radiomics, which is central to creating in-vivo and non-invasive pipelines for cancer detection and characterization. First, it proposes an open-source Hardware/Software toolchain to deploy accurate, fast, and efficient image registration pipelines transparently employing hardware accelerators. Then, it proposed an open-source framework for accelerating the inference stage of different segmentation Convolutional Neural Networks. Finally, Chimera proposes a methodology and tool for identifying, segmenting and characterizing cancer in a non-invasive fashion, exploiting the radiomic approach.

Andrea DAMIANI – XXXV Cycle

ON HOW TO FACILITATE HARDWARE ACCELERATION OF MACHINE LEARNING FOR NON-EXPERTS IN HARDWARE DESIGN OVER THE EDGE, THE FOG, AND THE CLOUD

Supervisor: Prof. **Marco Santambrogio**

Abstract:

This Ph.D. research project investigates how to facilitate Machine Learning (ML) experts in exploiting the benefits of domain-specific architectures (DSAs) for hardware acceleration without requiring expertise in hardware design and development.

The three main research themes that emerge from this question are: the automatic translation of ML models into hardware accelerators, increasing the ease of access to the technological platforms that enable hardware acceleration across the network's different levels (the Edge, the Fog, and the Cloud), and programming models that support ML experts in exploiting hardware acceleration over such distributed infrastructures.

At the core of the work, there are two main contributions: Entree, a toolchain exploiting partial dynamic reconfiguration for deploying arbitrarily large decision tree ensembles' inference over embedded devices mounting an FPGA, and the Virtual Sensor Domain-Specific Language (DLS), an extension of the C++ programming language that allows data scientists to create abstract sensors without having to handle the complexity of the underlying Edge-Fog-Cloud infrastructure.

Building on these contributions, the project also investigates how to facilitate the use of FPGAs in the Cloud and Fog. These contributions altogether provide a positive answer to the overarching research question, paving the way toward extending the approach to ML models other than decision tree ensembles.

Overall, the research project aims to build a solid, extensible, and open foundation for bridging the gap between ML and hardware acceleration, simplifying the growth of the Artificial Intelligence of Things, and contributing to the development of new intelligent applications for a wide range of industries.

PhD Committee

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