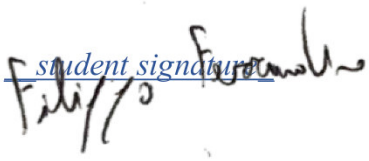
PhD in Information Technology and Electrical Engineering
Università degli Studi di Napoli Federico II

PhD Student: Filippo Ferrandino

Cycle: XXXIX

Training and Research Activities Report

Year: First


student signature

Tutor: prof. Alessandro Cilardo


tutor signature

Co-Tutor: Gabriella Gentile

Date: November 10, 2024

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: **Author:**

1. Information:

- **PhD student:** **Filippo Ferrandino** **PhD Cycle: 39**
- **DR number:** **DR997213**
- **Date of birth:** **25/7/1996**
- **Master Science degree:** Computer Engineering
- **University:** University of Naples "Federico II"
- **Scholarship type:** *DM 117/2023*
- **Tutor: Alessandro Cilardo**
- **Co-tutor: Gabriella Gentile**
- **Period abroad:** ***Cira 2 mounths spents and 10 mounths to be spent***

2. Study and training activities:

Activity	Type	Hours	Credits	Dates	Organizer	Certificate
Ensuring Electronic Reliability Against CERN's Radiation Environment	Seminar	**2**	**0.4**	**1.12.2023**	UniNa	**Y**
Energy-Efficient Data Science	Seminar	**1**	**0.2**	**13.12.2023**	**Dr. Carlos Ordonez**	**Y**
Development of superconducting quantum devices at FBK	Seminar	**1**	**0.2**	**24.11.2023**	UniNa	**Y**
Multi-agent autonomous flight at Leonardo Labs	Seminar	**1**	**0.2**	**21.12.2023**	UniNa	**Y**
AI @ The Deep Edge	Seminar	**21**	**4.2**	3.1.24-2.2.24	**STmicroelectronics**	**Y**
Virtualization technologies and their applications	Courses		**5**	26.2.2024	Luigi De Simone	**Y**
Edoardo Giusto research past, present and future	Seminar	**1**	**0.2**	26..2.24	**UniNa**	**Y**
C-Code Optimization for ARM based embedded Systems	Seminar	**6**	**1.2**	6.03.2024	**Giovanni Di Sirio, Mario Barbareschi**	**Y**
Industrial Embedded Systems Design with the ARM Architecture	Courses		**4**	26.06.2024	**Mario Barbareschi**	**Y**

2.1. Study and training activities - credits earned

	Courses	Seminars	Research	Tutorship	Total
Bimonth 1		1	4		5
Bimonth 2	5	4.2	5		14.2
Bimonth 3		1.4	4		5.4
Bimonth 4	4		4		8
Bimonth 5			3		3
Bimonth 6			6		6
Total	9	6.6	26	-	41.6
Expected	30 - 70	10 - 30	80 - 140	0 – 4.8	

3. Research activity:

The scope of my research I deal with is the improvement of autonomous aircraft guidance, an activity that is part of a European Project. Although modern aircraft normally use autonomous guidance systems during the cruise phase, during the takeoff and landing phases the guidance is entrusted to the pilots, with the possibility of partial assistance.

Multipliers Approximate for Neural Network

The first step involved a state-of-the-art analysis of approximate multipliers specifically for FPGA. Encouraged by promising results from the literature, I replicated experiments based on the few publications that provided open-source code for approximate multipliers. In these studies, all comparisons were made either against exact multipliers cited in previous research or those provided by the tools used. I compared these to the best-performing exact multiplier designed for FPGA, the results showed that some of the most optimized approximate multipliers in the literature consume more power than this exact multiplier.

Physical Unclonable Function for FPGA

Another experimental effort was in developing a Physical Unclonable Function (PUF) by programming specific FPGA LUT configurations. In the context of ensuring that the hardware processing the data remains authentic and unaltered, PUF technology is emerging as a robust solution. I implemented key PUF metrics, and while many achieved values close to an ideal PUF, Uniqueness remained relatively low. Future research will focus on improving this metric, testing on a broader range of boards, and evaluating performance across varying environmental conditions.

Evaluating AI Model Support on Embedded Systems

As part of a collaborative task between my research work and CIRA, I investigated which components might best support AI models on embedded systems. After extensive optimization and measurements, GPU-based devices emerged as the most effective in my scenario, particularly due to their scalability and energy efficiency. If higher power is required, the same optimized engine can be adapted to high-performance Nvidia devices or cloud systems. Meanwhile, in applications that demand exceptionally low power consumption, even at the expense of some quality metrics, AI models on microcontrollers or directly on sensors allow for an energy efficiency that other platforms cannot match, though their energy-per-frame metric may not be the lowest.

4. Research products:

Mario Barbareschi, Salvatore Barone, Filippo Ferrandino, Nicola Mazzocca
Designing Approximate Neural Network: a GPU-Enabled Multi-objective Approach
Future Generation Computer System - Q1 Journal
Submitted on February 2024, and 2° review stage in May 2024

Title: SCSC - Sistema Controllo e Smistamento delle Comunicazioni
Type: Tools
Status: Released
Description: Inspect-NN is a framework designed to facilitate the creation of approximate Artificial Neural Networks (ANNs) by leveraging GPUs for efficient emulation and multi-objective optimization. The tool targets reducing the hardware overhead of accelerators and minimizing the accuracy loss caused by approximation. It addresses the challenges of using Approximate Computing (AxC) by quantifying the error introduced through approximation, which is a complex task due to the costly software emulation of approximate operations. Inspect-NN aims to optimize the trade-offs between energy savings and accuracy loss, enabling the deployment of ANNs on medium and low-end devices while maintaining reasonable performance.

5. Conferences and seminars attended

The 14th IEEE International Conference On Cloud Computing Technology And Science

6. Periods abroad and/or in international research institutions

This research is framed within the SESAR Strategic Research Agenda for the Digital European Sky [Single European Sky ATM Research 3 Joint Undertaking, Digital European Sky – Strategic Research and Innovation Agenda, Publications Office of the European Union, 2020]. The agenda addresses various pillars and research topics aimed at meeting the growing demands of air transport while ensuring a high level of sustainability. Two key needs are particularly relevant to this work: (i) the development of new Air Traffic Management ATM technologies through SESAR projects to enhance ATM performance, and (ii) smart management of airport capacity to align it with air transport demands. Within this context, the research focuses on specific enabling technologies related to automatic take-off and landing.

A crucial aspect of ensuring safety and efficiency in these automated processes is situational awareness. As automation levels rise in aviation, the ability to maintain a clear understanding of the surrounding environment becomes increasingly important. Situational awareness enables both human operators and automated systems to perceive relevant factors, comprehend their implications, and anticipate future developments, facilitating timely and effective decision-making. This is especially critical in high-stakes environments like air traffic management, where complex, dynamic, and safety-critical operations are routine.

Situational awareness is the ability to perceive, understand, and anticipate the environment in real-time to support decision-making, crucial in automated, complex, and safety-critical contexts like aviation and air traffic control.

The concept of situational awareness can be broken down into three key components:

Perception: Gather relevant information from the environment, such as objects, events, or people around the system.

Comprehension: Analyze the gathered data to assess the current situation, identifying potential obstacles and classifying them by type.

Projection: Predict future developments based on current information, including estimating the speed and direction of obstacles to determine potential collisions and triggering alerts as needed.

CIRA(*PNRR - DM 117/2023)*: 12 months expected

Abroad Tutor: Gigante Gabriella

Period abroad completed: 2 months

Period remaining: 10 months

Plans for Next Year for CIRA

Task Analysis

- Characterization of Ground Movements: Perform a detailed analysis and charac terization of various ground movements
- EASA Concept Paper: Reviewthe EASA concept paper regarding AI trust worthi ness to ensure compliance and best practices
- Achievable Accuracy: Evaluate achievable accuracy levels of the detections ystem

Task Development

- Conceptual Design: Develop a conceptual design for the proof of concept
- AI Algorithm Modeling: Model AI algorithms for integration into the system
- Deploymenton Hardware Target: Implement the system on the selected hardware
- Balancing Performance and Accuracy: Develop strategies for balancing performance with accuracy to optimize system functionality
- Hardware Customization: Customize hardware to meet specific project require ments..
- Simulated Testing: Conduct extensive testing in simulated environments to validate performance under various scenarios

Task Refinement and Testing

- Explainability Layer: Integrate an explainability layer to improve the interpretabil ity of the system's decisions

- Rigorous Testing: Perform rigorous testing of the developed solution to ensure reliability and performance

7. Tutorship

Not yet.