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

PhD Student: Narendra Patwardhan

Cycle: XXXVIII

Training and Research Activities Report

Year: First

Tutor: Prof. Carlo Sansone

Date: October 18, 2023

1. Information:

- **PhD student: Narendra Patwardhan**
- **DR number: DR996634**
- **Date of birth: 28/02/1995**
- **Master Science degree: Mechanical Engineering**
- **University: Michigan Technological University**
- **Doctoral Cycle: 38**
- **Scholarship type: *PNRR - DM 352 SIMAR GROUP s.r.l., Monte Urano (FM)***
- **Tutor: Prof. Carlo Sansone**

2. Study and training activities:

Activity	Type[1]	Hours	Credits	Dates	Organizer	Certificate[2]
Unleashing the Power of LLMs: a Historical Perspective on Generative AI	**Seminar**	**1**	**0.2**	**02/03/2023**	**Prof. Carlo Sansone & Prof. Stefano Marrone**	**Y**
Statistical Data Analysis for Science and Engineering Research	**Course**	**12**	**4**	**06/02/2023 - 16/02/2023**	**Prof. Roberto Pietrantuono**	**Y**
Introduction to Deep Learning	**Course**	**24**	**6**	**03/05/2023 - 20/06/2023**	**Prof. Giovanni Poggi & Prof. Diego Gragnaniello**	**Y**
Spring School on Transferable Skills	**Doctoral School**	**14**	**2**	**24/05/2023 - 25/05/2023**	**Dept. of Pharmacy, University of Naples Federico II**	**Y**
Nanoneuro: the power of nanoscience to explore the frontiers of neuroscience	**Seminar**	**1**	**0.2**	**03/05/2023**	**Prof. C. Forestiere**	**Y**
AI, Robots, and Society: Challenges and Opportunities for Social Innovation	**Seminar**	**1**	**0.2**	**25/05/2023**	**Prof. Bruno Siciliano**	**Y**
Symbiotic Control of	**Seminar**	**2**	**0.4**	**26/05/2023**	**Prof.**	**Y**

Wearable Soft Suits for human motion assistance and augmentation					**Fanny Ficuciello**	
Quantum communications with continuous variables of light	**Seminar**	**1.5**	**0.3**	**20/06/2023**	**Prof. Angela Cacciapuoti**	**Y**
Optimization of a mobile clinic routing and scheduling problem in equitable vaccination outreach	**Seminar**	**1**	**0.2**	**21/06/2023**	**Prof. Claudio Sterle & Prof. Maurizio Boccia**	**N**
What is Artificial Intelligence?	**Seminar**	**2**	**0.4**	**22/06/2023**	**Prof. Paolo Russo**	**N**
Online learning, Bandits, and Digital Marker	**Seminar**	**1**	**0.2**	**22/06/2023**	**Prof. Cesa-Bianchi**	**N**
Traffic Engineering with Segmented Routing: optimally addressing popular use cases	**Seminar**	**1**	**0.2**	**23/06/2023**	**Prof. V. Persico**	**N**
Insights into the Design of Transmit and Receive Coils for Ultra-High Field MRI	**Seminar**	**2**	**0.4**	**29/06/2023**	**Prof. Rita Massa & Prof. Giuseppe Ruello**	**Y**
BGP & Hot-Potato Routing: graceful and optimal convergence in case of IGP events	**Seminar**	**1**	**0.2**	**30/06/2023**	**Prof. V. Persico**	**N**
Academic Entrepreneurship	**Course**	**17**	**4**	**29/05/2023 - 22/06/2023**	**Prof. Pierluigi Rippa**	**Y**
International Summer School “Machine Vision”	**Doctoral School**	**24**	**4**	**04/09/2023 - 08/09/2023**	**University of Padova**	**Y**
Accelerate Robotics with MATLAB-Isaac Sim Integration	**Seminar**	**1**	**0.2**	**12/09/2023**	**MATLAB**	**N**
Building Wearable Assistants with First Person (Egocentric Vision): History, Challenges,	**Seminar**	**2**	**0.4**	**15/09/2023**	**ICIAP-23**	**Y**

Opportunities and Applications						
Remote Physiological Sensing: State of the Art and Applications	**Seminar**	**2**	**0.4**	**15/09/2023**	**ICIAP-23**	**Y**
Simulating stochastic processes using quantum simulators	**Seminar**	**2**	**0.4**	**25/09/2023**	**Prof. P. Lucignano**	**N**
MATLAB Academic Forum Research and Teaching	**Seminar**	**4**	**0.8**	**28/09/2023**	**MATLAB**	**Y**

1) Courses, Seminar, Doctoral School, Research, Tutorship
2) Choose: Y or N

2.1. Study and training activities - credits earned

	Courses	Seminars	Research	Tutorship	Total
Bimonth 1	**0**	**0**	**7**	**0**	**7**
Bimonth 2	**0**	**0**	**13**	**0**	**13**
Bimonth 3	**0**	**0.2**	**10**	**0**	**10.2**
Bimonth 4	**12**	**2.7**	**1**	**0**	**15.7**
Bimonth 5	**4**	**0**	**1**	**0**	**5**
Bimonth 6	**4**	**2.2**	**3**	**0**	**9.2**
Total	**20**	**5.1**	**35**	**0**	**60.1**
Expected	**30 - 70**	**10 - 30**	**80 - 140**	**0 – 4.8**	

3. Research activity:

Throughout the current year, my research efforts have been dedicated to enhancing the efficiency of neural network-based models across various domains, including Natural Language Processing (NLP), Computer Vision, and Health Monitoring and make them accessible at edge. Below, I will provide an overview of the topics I've explored, the methodologies employed, and the outcomes achieved in each area.

1. Sustainability of Large Language Models:

At the start of the year, I performed an extensive study of generative NLP models, where I systematically surveyed the landscape of transformers in NLP, with a particular focus on text-based applications. Utilizing the PapersWithCode platform as a starting resource, I compiled an initial corpus of applications. To ensure conciseness, accuracy, and real-world relevance, I employed a series of heuristic-based filtering steps, reducing the dataset from 572 papers to a more manageable size. This work culminated in the creation of a classification schema for the refined entries and a summary of the most impactful papers. The results of this research were

published in the survey paper titled "Transformers in the Real World." It was noted that, despite a prevalent focus on larger models with increasing parameter counts in research, practical applications often rely on models with fewer than one billion parameters.

Subsequently, in collaboration with REAL AI, I delved into bringing sustainability to large language models. We sought to address challenges related to accessibility and extensibility. During our feasibility study, we proposed techniques to mitigate common failure modes of generative models, focusing on automated fairness metrics computation. Our methodology for addressing high memory requirements of large models centered around two key factors: providing sustainable alternatives to internal components of transformers and identifying essential architectural additions. These findings were initially presented at the Ital-IA conference. Building upon the EU AI act, our research scope expanded to encompass human-centric design, leading to the creation of the "Hominis" architecture, which was presented in a paper at the HCAI4U conference. In the same context of making large language models sustainable, I collaborated with colleagues in AI Ethics to explore the impact of programmability and accessibility on justice, and these findings were also shared at the HCAI4U conference in a separate paper. We have submitted the ISCRA-B grant for compute to train this architecture on web-scale corpus.

2. Overcoming Resource Scarcity in Computer Vision:

Leveraging my background in robotics and computer vision, I collaborated with REAL AI to tackle data-scarcity and modeling inefficiency in geophysics. Together, we developed a domain-specific simulator capable of generating synthetic images to mitigate data scarcity. This simulator incorporated expert knowledge and actively minimized the disparity between synthetic and limited labeled data. The resulting dataset was made publicly available, and our methodology was documented in a paper presented at ICIAP-23.

Additionally, I introduced a novel architecture called "VeerNet," which integrates the strengths of U-Net and transformers. This architecture was applied to the domain of well-log annotation. The synthetic dataset created earlier was combined with proprietary data, and the resulting model found practical use in production. A detailed account of this architecture was presented in a separate journal paper in the Journal of Imaging.

3. Health Monitoring:

In line with my PhD sponsorship from the SIMAR Group, the domain of non-invasive health monitoring holds particular significance. Our overarching objective is to develop a smart seat that can continuously monitor user health and facilitate natural language-based communication. My earlier foray in NLP is instrumental in making the natural language aspect efficient with limited resources. This year, I completed a feasibility study to ascertain the

viability of proposed features within the constraints of available technology and their suitability for users. Furthermore, I presented an architectural report outlining the various components of this project. A key area of focus is addressing the challenge of asynchronous readings, ensuring continuous data recording even when the user is not in direct contact with or within the range of sensors. This work is currently ongoing and will be a central focus of the upcoming year's activities.

4. Research products:

1. "Transformers in the Real World: A Survey on NLP Applications."
Narendra Patwardhan, Stefano Marrone, and Carlo Sansone.
Information 14.4,
Published, 2023

2. "Responsible and Reliable AI at PICUS Lab."
Narendra Patwardhan, Lidia Marassi, Michela Gravina, Antonio Galli, Monica Zuccarini, Tannistha Maiti, Tarry Singh, Stefano Marrone, and Carlo Sansone.
Convegno Nazionale CINI sull'Intelligenza Artificiale, Ital-IA 2023,
Published, 2023.

3. "VeerNet: Using Deep Neural Networks for Curve Classification and Digitization of Raster Well-Log Images"
Quamer Nasim, Narendra Patwardhan, Tannistha Maiti, Stefano Marrone, and Tarry Singh
Journal of Imaging 9(7),
Published, 2023

4. "Digitizer: A Synthetic Dataset for Well-Log Analysis"
Quamer Nasim, Narendra Patwardhan, Javed Ali, Tannistha Maiti, Stefano Marrone, Tarry Singh, and Carlo Sansone
22nd International Conference on Image Analysis and Processing, ICIAP-23,
Published, 2023

5. "Can Justice Be a Measurable Value for AI? Proposed Evaluation of the Relationship Between NLP Models and Principles of Justice"
Lidia Marassi, Narendra Patwardhan, and Francesco Gargiulo
The First Workshop on User Perspectives in Human-Centred Artificial Intelligence, HCAI4U
Published, 2023.

6. "Designing Human-Centric Foundation Models"
Narendra Patwardhan, Shreya Shetye, Lidia Marassi, Monica Zuccarini, Tannistha Maiti, and Tarry Singh

The First Workshop on User Perspectives in Human-Centred Artificial Intelligence, HCAI4U Published, 2023.

5. Conferences and seminars attended

22nd International Conference on Image Analysis and Processing, ICIAP-23, Udine, Italy, 11/09/2023-15/09/2023. Presented a paper "Digitizer: A Synthetic Dataset for Well-Log Analysis" as a poster.

6. Activity abroad:

N/A

7. Tutorship

N/A