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

PhD Student: Giuseppe Guarino

Cycle: XXXVIII

Training and Research Activities Report

Year: First

Tutor: prof. Giovanni Poggi

Co-Tutor:
prof. Giuseppe Scarpa (UniParthenope)
Gemine Vivone (CNR IMAA)

Date: October 18, 2023

1. Information:

➢ **PhD student: Guarino Giuseppe**
➢ **DR number: DR996619**
➢ **Date of birth: 22/06/1997**
➢ **Master Science degree: Automation Engineering and Robotics**
➢ **University: Università degli Studi di Napoli Federico II**
➢ **Doctoral Cycle: XXXVIII**
➢ **Scholarship type: CNR Istituto di Metodologie per l'Analisi Ambientale (IMAA)**
➢ **Tutor: prof. Giovanni Poggi**
➢ **Co-tutor: prof. Giuseppe Scarpa (UniParthenope), Gemine Vivone (CNR IMAA)**

2. Study and training activities:

Activity	Type[1]	Hours	Credits	Dates	Organizer	Certificate[2]
Academic Entrepreneurship	Courses	17	4	29/05/2023 – 11/07/2023	Prof. Pierluigi Rippa	Y
Visione per sistemi robotici	Courses	72	9	03/03/2023 – 09/06/2023	Prof. Davide Cozzolino	Y
How to boost your phd	Courses	16	4	11/01/2023 – 01/03/2023	Prof. Antigone Marino	Y
Using Deep Learning Properly	Courses	10	4	10/01/2023 - 24/01/2023	Dr. Andrea Apicella	Y
IEEE International Geoscience and Remote Sensing Symposium (IGARSS) 2023	Seminar	15.5	3.1	17/07/2023 – 21/07/2023	Dino Ienco, Charlotte Pelletier, Paolo Gamba, Francescopaolo Sica, Paul Aimé, Sveinn E. Armannsson, Alejandro C. Frery	Y
Pansharpening by convolutional neural networks (IGARSS2023)	Seminar	3	0.6	16/07/2023	Prof. Giuseppe Scarpa and Eng. Matteo Ciotola	Y
Holographic visualization: signal processing and technological challenges	Seminar	1	0.2	06/04/2023	Prof. Peter Schelkens	Y
Unleashing the Power of LLMs: A Historical Perspective on Generative AI	Seminar	1	0.2	02/03/2023	Prof. Tarry Singh	Y

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What's Up with Image and Video Forensics?	Seminar	1	0.2	02/03/2023	Prof. Fernando Pérez-González	Y
Human Centric Visual Analysis - Hand, Gesture, Pose, Action, and Beyond	Seminar	1	0.2	13/02/2023	Dr. Joe (Zhou) Ren	Y
The Super Neuron Model – A new generation of ANN-based Machine Learning and Applications	Seminar	1	0.2	09/02/2023	Moncef Gabbouj	Y
Threat Hunting & Incident Response	Seminar	2	0.4	13/12/2022	Vladimir Kurdin (Group-IB)	Y
Game Theory for Information Engineering	Seminar	3	0.6	13/12/2022	Prof. Leonardo Badia	Y
Digital Forensics	Seminar	2	0.4	06/12/2022	Artem Artemov (Group-IB)	Y
From Handcrafted to End-to-End Learning, and Back: a Journey for Multi-Object Tracking	Seminar	2	0.4	02/12/2022	Prof. Dr. Laura Leal-Taixé	Y
Privacy and Data Protection	Seminar	2	0.4	22/11/2022	Dr. Stefano Mele	Y
Complex Network Systems: Introduction and open challenges	Seminar	1	0.2	17/11/2022	Prof. Pietro de Lellis	Y
Study of Sentinel 5P L1 data and CAMS maps of PM2.5	Research		2.0	01/09/2023 - 31/10/2023		N
Implementation of an algorithm to remap Sentinel 5P images to CAMS maps resolution.	Research		2.0	01/09/2023 - 31/10/2023		N
Research of possible deep learning architectures to estimate PM2.5 from radiance data.	Research		1.0	01/09/2023 - 31/10/2023		N
Research of possible deep learning solution to estimate Sentinel 5P L2 data from radiance images of Sentinel 5P	Research		1.0	01/09/2023 - 31/10/2023		N
Preparation of major review of journal paper "Band-wise Hyperspectral Image Pansharpening using CNN Model Propagation" to IEEE Trans. on Geoscience and Remote Sensing	Research		1.0	01/09/2023 - 31/10/2023		N

Presentation of conference paper "An Unsupervised CNN-Based Hyperspectral Pansharpening Method" at IEEE IGARSS 2023	Research		0.5	21/07/2023		N
Preparation of major review of journal paper "Band-wise Hyperspectral Image Pansharpening using CNN Model Propagation" to IEEE Trans. on Geoscience and Remote Sensing	Research		1.5	01/07/2023 - 31/08/2023		N
Preparation of major review of letter paper "PCA-CNN Hybrid Approach for Hyperspectral Pansharpening" to IEEE Geoscience and Remote Sensing Letters (GRSL)	Research		1.0	01/07/2023 - 31/08/2023		N
Search for combined satellite images from two different satellites for a possible work on air pollutants retrieval.	Research		0.5	01/05/2023 - 30/06/2023		N
Preparation of camera-ready version of conference paper "An Unsupervised CNN-Based Hyperspectral Pansharpening Method" to IGARSS 2023	Research		1.0	01/05/2023 - 30/06/2023		N
Preparation of camera-ready version of conference paper "Pansharpening by Efficient and Fast Unsupervised Target-Adaptive CNN" to IGARSS 2023	Research		1.0	01/05/2023 - 30/06/2023		N
Preparation of major review of journal paper "Band-wise Hyperspectral Image Pansharpening using CNN Model Propagation" to IEEE Trans. on Geoscience and Remote Sensing	Research		2.0	01/05/2023 - 30/06/2023		N
Preparation of the letter paper "PCA-CNN Hybrid Approach for Hyperspectral	Research		1.5	01/05/2023 - 30/06/2023		N

Pansharpening" to IEEE Geoscience and Remote Sensing Letters (GRSL)						
Study of state-of-the-art of air pollutants retrieval algorithms using satellite images.	Research		2.0	01/03/2023 - 30/04/2023		N
Study of carbon monoxide retrieval algorithms for Sentinel 5P Mission	Research		1.0	01/03/2023 - 30/04/2023		N
Study of state-of-the-art of Diffusion models	Research		1.0	01/03/2023 - 30/04/2023		N
Validation experiments for a Deep Learning based method for Hyperspectral Pansharpening	Research		1.0	01/03/2023 - 30/04/2023		N
Preparation of conference paper "An Unsupervised CNN-Based Hyperspectral Pansharpening Method" for IEEE IGARSS 2023	Research		2.0	01/01/2023 - 28/02/2023		N
Study of the state-of-the-art of Hyperspectral Pansharpening	Research		5.0	01/11/2022 - 28/02/2023		N
Study of PRISMA and Sentinel 5P missions	Research		3.0	01/11/2022 - 31/12/2022		N
Implementation of a Deep Learning-Based technique for Hyperspectral Pansharpening applications	Research		1.0	01/11/2022 - 31/12/2022		N

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	2.4	6	0	8.4
Bimonth 2	4	0.4	5	0	9.4
Bimonth 3	4	0.6	5	0	9.6
Bimonth 4	9	0.0	6	0	15.0
Bimonth 5	4	3.7	3	0	10.7
Bimonth 6	0	0.0	7	0	7.0
Total	21	7.1	32	0	60.1
Expected	30 - 70	10 - 30	80 - 140	0 – 4.8	

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3. Research activity:

The research activity conducted in this first year can be divided in two main fields, both regarding a particular use of satellite images:

1. *Hyperspectral pansharpening*
2. *Air pollutants detection through satellite images*

Hyperspectral pansharpening

Hyperspectral images are widely employed to address such diverse applications as unmixing, change detection, object detection, semantic segmentation, classification. However, due to technological constraints, the high spectral resolution imposes a relatively low geometric resolution compared to other imaging systems, e.g. multispectral sensors. Therefore, it is very useful to dispose of efficient and effective pansharpening tools capable to increase the spatial resolution of the hyperspectral (HS) images while preserving their spectral quality thanks to the fusion with a higher-resolution panchromatic (PAN) image [1]. Most of the current solutions are actually generalizations of methods originally conceived for the more familiar multispectral (MS) image pansharpening problem [3]. Among these, Component substitution (CS) [3, 4] and Multi-Resolution Analysis (MRA) [5, 6] are the most popular ones. In addition, Bayesian [7, 8, 9] or matrix factorization [10] solutions are also employed. In the last years, lots of deep learning-based solutions have been devised for the MS-PAN pansharpening problem [11, 12, 13, 14, 15, 16, 17, 18] as well as for the HS-PAN fusion problem [19, 20, 21, 22].

Following this trend and motivated by a recent challenge on hyperspectral pansharpening [2], in this first year we proposed two different deep learning-based solutions. The first leveraging on a model propagation strategy [J1] whereas the second is a hybrid solution that combines deep learning potentials with the strength of principal component analysis (PCA) [C1, L1].

Moreover, we also proposed a work focused on classical multispectral pansharpening [C2].

Air pollutants detection through satellite images

The utilization of satellite imagery for air pollutant detection represents a challenge that has been addressed in various space missions. Opting for satellite images over ground stations offers numerous advantages, including global coverage, reduced sensor maintenance, and cost savings.

In this first year of research, we have focused on the Copernicus Sentinel-5 Precursor mission. This is the first Copernicus mission dedicated to monitoring the atmosphere.

Using hyperspectral image of radiance alongside irradiance images and various meteorological data, Sentinel 5P can effectively estimate diverse air pollutants such as CO, NO2, HCHO, CH4, and SO2.

A central objective of our research is to establish a correlation between hyperspectral images and air pollutant levels. Subsequently, we aim to develop a lightweight and fast deep learning-based solution for air pollutant estimation using Sentinel 5P images. This will pave the way for the application of similar techniques to images from other satellites with higher spatial resolution.

References

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4. Research products:

- ***Journal Papers:***
  - *[J1] G. Guarino, M. Ciotola, G. Vivone, G. Scarpa, 'Band-wise Hyperspectral Image Pansharpening using CNN Model Propagation', IEEE Trans. on Geoscience and Remote Sensing (In review – "Major Review" received)*
- ***Letter Papers:***
  - *[L1] G. Guarino, M. Ciotola, G. Vivone, G. Poggi, G. Scarpa, 'PCA-CNN Hybrid Approach for Hyperspectral Pansharpening', IEEE Geoscience and Remote Sensing Letters (To appear in Scopus).*
- ***Conference proceeding:***
  - *[C1] G. Guarino, M. Ciotola, G. Vivone, G. Poggi, G. Scarpa, 'An unsupervised CNN-based hyperspectral pansharpening method', IEEE IGARSS 2023, pp. 5982-5985, 2023 (To appear in Scopus)*
  - *[C2] M. Ciotola, G. Guarino, A. Mazza, G. Poggi, G. Scarpa, 'Pansharpening by efficient and fast unsupervised target-adaptive CNN", IEEE IGARSS 2023, pp. 5579-5582, 2023 (To appear in Scopus)*

5. Conferences and seminars attended

- **IEEE International Geoscience and Remote Sensing Symposium (IGARSS) 2023**
  - Dates: 16/07/2023 – 21/07/2023
  - Location: Pasadena, California
  - Author and presenter of the paper: "*An unsupervised CNN-based hyperspectral pansharpening method*"
- **Tutorial: Pansharpening by convolutional neural networks (IGARSS2023)**
  - Date: 16/07/2023
  - Speakers: Prof: Giuseppe Scarpa and Eng. Matteo Ciotola

6. Activity abroad:

None

7. Tutorship

None