



PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Massimiliano Gargiulo

XXXIII Cycle

Training and Research Activities Report – Second Year

Tutor: Giuseppe Ruello



1. Information

Massimiliano Gargiulo, Master Degree in Telecommunication Engineering – University of Naples “Federico II”

XXXIII Cycle - ITEE - Università di Napoli Federico II

Tutor: Prof. Giuseppe Ruello

2. Study and Training activities

During my first year of the Ph.D I have taken the following courses:

- ✓ Ad Hoc: Machine Learning
Credits earned: 4.2
- ✓ Ad Hoc: Internet Censorship: enforcement, detection, and circumvention
Credits earned: 2
- ✓ Ad Hoc: Artificial Intelligence for Energy and Environmental Systems
Credits earned: 0.8

and I have attended the following seminars:

- ✓ Computational and Machine Learning Methods for Complex Ecosystems
- ✓ Designer Matter: Meta-Material Interactions with Light, Radio Waves and Sound
- ✓ Presentazione ADI: Vittorie, Sfide, Obiettivi
- ✓ Microwave Sensing Through the Subsurface for Addressing the Water Puzzle
- ✓ Medical Thermal Therapy and Monitoring using Microwave Inverse Scattering
- ✓ Forest mapping from Sentinel-1 InSAR data
- ✓ Digital Beamforming for Radio Frequency Interference Suppression in Synthetic Aperture Radar
- ✓ Modeling of Subsurface Scattering from Ice Sheets for Pol-InSAR Applications
- ✓ An Update on the NASA-ISRO SAR Mission and an Architecture for its Successor
- ✓ Forest Structure Characterization from SAR Tomography
- ✓ Onboard Quantization for Interferometric and Multichannel SAR Systems
- ✓ TerraSAR-X/TanDEM-X Science Meeting 2019

Training and Research Activities Report – First Year

PhD in Information Technology and Electrical Engineering – XXXIII Cycle

Massimiliano Gargiulo

In the following table is depicted a summary of the activities presented above:

| Student: Massimiliano Gargiulo massimiliano.gargiulo@unina.it | | Tutor: Giuseppe Ruello giuseppe.ruello@unina.it | | Cycle XXXIII | | | | | | | | | | | | | | | | | | | | | | | |
|--|----------------|--|----|--------------|---|------|------|---------|----------------|-----|----|-----|---|-----|-----|---------|----------------|---|---|---|---|---|---|---------|-------|-------|--------|
| | Credits year 1 | | | | | | | | Credits year 2 | | | | | | | | Credits year 3 | | | | | | | | Total | Check | |
| | Estimated | 1 | 2 | 3 | 4 | 5 | 6 | Summary | Estimated | 1 | 2 | 3 | 4 | 5 | 6 | Summary | Estimated | 1 | 2 | 3 | 4 | 5 | 6 | Summary | | | |
| Modules | 18 | 0 | 0 | 6 | 0 | 3 | 12 | 21 | 9 | 0 | 0 | 7 | 0 | 0 | 0 | 7 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 30-70 |
| Seminars | 13 | 0.8 | 0 | 1.3 | 0 | 2 | 1.1 | 5.2 | 6 | 0.2 | 0 | 0.8 | 0 | 3.6 | 1.2 | 5.8 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 10-30 |
| Research | 34 | 9.2 | 10 | 2.7 | 7 | 5.1 | 0 | 34 | 42 | 9.8 | 10 | 4.2 | 7 | 7.4 | 8.8 | 47.2 | 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 81.2 | 80-140 |
| | 65 | 10 | 10 | 10 | 7 | 10.1 | 13.1 | 60.2 | 57 | 10 | 10 | 12 | 7 | 11 | 10 | 60 | 57 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 120.2 | 180 |

3. Research activity

In the first year of my Ph.D I focused the research activity on two main topics:

- Deep Learning approaches in Remote Sensing Applications [4.a.*]
- 5G Channel Modeling in urban environment [7.1]

Here I briefly explain each of which:

- Deep Learning is a topic of interest for the remote sensing (RS) community arising in such diverse formulations such as multitemporal analysis, image restoration, super-resolution and so on.

The main topics of this research activity include the following:

- Single-sensor data fusion for RS super-resolution;
- Processing of RS time-series for land use/land cover classification.

In the research activity 1), I have considered the Sentinel-2 bands that are provided at different spatial resolutions, from 60-m to 10-m.

Firstly, I have proposed a CNN-based data fusion technique for the super-resolution of the 20-m short wave infrared (SWIR) band. This is accomplished by fusing the target band with the finer-resolution ones. In addition I have also tested the use of the super-resolved band to detect water basins through the Modified Normalized Difference Water Index (MNDWI).

Therefore, encouraged by very promising results I have considered an improved version with four main integrations:

- extension with more data and more complex architectures,
- the use of the residual learning strategy,
- the batch normalization, both (i) and (ii) aimed to speed-up the learning,
- a high-pass preprocessing of the input,
- the extension to all 20-m bands,
- more complex and more accurate losses, and, finally,
- an extensive analysis on computational time.

In the research activity 2), I have proposed a CNN-based land use classification exploiting the synergetic use of Sentinel-1 and Sentinel-2 data. In particular, the objective of this activity is to detect water presence and rice growing in Albufera Park. This is accomplished by using Sentinel-1 data to feed the CNN. To begin the CNN optimization algorithm I have considered a water map and rice map from the map provided by the L2A product of the Sentinel-2 data. To improve the performance of this approach I will consider water/rice maps from Google Earth images with higher spatial resolution than Sentinel-2.

To reach this aim, the following references has been mainly considered and studied:

- [1] Chao Dong, Chen Change Loy, Kaiming He, and Xiaoou Tang, "Image super-resolution using deep convolutional networks," *IEEE transactions on pattern analysis and machine intelligence*, vol. 38, no. 2, pp. 295–307, 2016.
- [2] Junfeng Yang, Xueyang Fu, Yuwen Hu, Yue Huang, Xinghao Ding, and John Paisley, "Pannet: A deep network architecture for pan-sharpening," pp. 5449–5457, 2017.
- [3] Kaiming He, Xiangyu Zhang, Shaoqing Ren, and Jian Sun, "Deep residual learning for image recognition," pp. 770–778, 2016.
- [4] Charis Lanaras, José Bioucas-Dias, Silvano Galliani, Emmanuel Baltsavias, and Konrad Schindler, "Super-resolution of Sentinel-2 images: Learning a globally applicable deep neural network," *arXiv preprint arXiv:1803.04271*, 2018.
- [5] S. t. Wu and S. A. Sader, "Multipolarization SAR data for surface feature delineation and forest vegetation characterization," *IEEE Trans. Geosci. Remote Sens.*, vol. GE-25, no. 1, pp. 67–76, 1987.
- [6] Tianxiang Zhang, Jinya Su, Cunjia Liu, Wen-Hua Chen, Hui Liu, and Guohai Liu, "Band selection in Sentinel-2 satellite for agriculture applications," in *Automation and Computing (ICAC), 2017 23rd International Conference on*. IEEE, 2017, pp. 1–6.
- [7] Y. Du, Y. Zhang, F. Ling, Q. Wang, W. Li, and X. Li, "Water bodies mapping from sentinel-2 imagery with modified normalized difference water index at 10-m spatial resolution produced by sharpening the swir band," *Remote Sensing*, vol. 8, no. 4, pp. 354, 2016.
- [8] Donato Amitrano, Gerardo Di Martino, Antonio Iodice, Daniele Riccio, and Giuseppe Ruello, "Unsupervised rapid flood mapping using Sentinel-1 GRD SAR images," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 56, no. 6, pp. 3290–3299, 2018.

- b. The mm-Waves have been identified as a promising technology since higher data-rate, lower latency and lower power consumption than 4G technology are achieved. However, the bottleneck of the use of such high frequencies is related to attenuation and penetration through buildings to allow outdoor-indoor communications. Therefore, it is important to provide a complete characterization of the wireless channel to above-mentioned transmission frequencies. This research activity has been carried out in several phases. In a first phase, the classical study of the channel modeling in urban environments has been approached and I have tested the deterministic ray-tracing-based channel model (that is already used in the 3G and 4G case) on EXACT+IDL software. Then, in order to extend the case of study I have considered the atmospheric attenuation by gases in complex environment, in particular water vapour and oxygen. Furthermore, the attenuation by rain is also included in the model. Finally, some simulations have been carried out in order to compare the results in presence or in absence of the atmospheric attenuation.

To reach this aim, the following references has been mainly considered and studied:

- [1] Robert E Collin, *Antennas and radiowave propagation*, McGraw-Hill, 1985.

- [2] Theodore S Rappaport, Yunchou Xing, George R MacCartney Jr, Andreas F Molisch, Evangelos Mellios, and Jianhua Zhang, “Overview of millimeter wave communications for fifth-generation (5G) wireless networks-with a focus on propagation models,” arXiv preprint arXiv:1708.02557, 2017.
- [3] Tan Kim Geok, F Hossain, MN Kamaruddin, Noor Ziela Abd Rahman, Sharlene Thiagarajah, Alan Tan Wee Chiat, and CP Liew, “A comprehensive review of efficient ray-tracing techniques for wireless communication,” International Journal on Communications Antenna and Propagation, vol. 8, no.2, pp. 123–136, 2018.
- [4] “Attenuation by atmospheric gases”, Recommendation ITU-R P.676-11 (09/2016).
- [5] Mansoor Shafi, Jianhua Zhang, Harsh Tataria, Andreas F Molisch, Shu Sun, Theodore S Rappaport, Fredrik Tufvesson, Shangbin Wu, and Koshiro Kitao, “Microwave vs. millimeter-wave propagation channels: Key differences and impact on 5G cellular systems,” IEEE Communications Magazine, vol. 56, no. 12, pp. 14–20, 2018.
- [6] Shihao Ju and Theodore S Rappaport, “Millimeter-wave extended NYUSIM channel model for spatial consistency,” arXiv preprint arXiv:1808.07099, 2018.

- [7] Jae-Hyun Lee, Jeong-Sik Choi, and Seong-Cheol Kim, “Cell coverage analysis of 28 ghz millimeter wave in urban micro-cell environment using 3-d ray tracing,” IEEE Transactions on Antennas and Propagation, vol. 66, no. 3, pp. 1479–1487, 2018.

4. Products

a. Publications:

1. M Gargiulo, A Mazza, R Gaetano, G Ruello, G Scarpa, Fast Super-Resolution of 20 m Sentinel-2 Bands Using Convolutional Neural Networks - Remote Sensing
2. M Gargiulo, DAG Dell'Aglio, A Iodice, D Riccio, G Ruello, A CNN-Based Super-Resolution Technique for Active Fire Detection on Sentinel-2 Data - PIERS 2019
3. M Gargiulo, Advances on CNN-based super-resolution of Sentinel-2 images - IGARSS 2019
4. M Gargiulo, DAG Dell'Aglio, A Iodice, D Riccio, G Ruello, Semantic Segmentation using Deep Learning: A case of study in Albufera Park, Valencia - MetriAgriFor 2019
5. DAG Dell'Aglio, M Gargiulo, A Iodice, D Riccio, G Ruello, Active Fire Detection in Multispectral Super-Resolved Sentinel-2 Images by Means of Sam-Based Approach - RTSI 2019

5. Conferences and Seminars

I have taken part at the following conference/seminar:

- a. International Geoscience and Remote Sensing Symposium (IGARSS) '19
- b. PIERS '19
- c. RTSI '19

d. MetriAgriFor 2019

6. Activity abroad

I have spent four months abroad at the DLR, Oberpfanfenhoffen, France.

7. Tutorship

Co-tutor of a Master Degree thesis student:

1. SOFTWARE PER LA PREVISIONE DELLA RADIOCOPERTURA IN AREE URBANE PER I SISTEMI 5G - Student: Paolo D'Antonio, Supervisor: Antonio Iodice.