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 – First Year

Tutor: Giuseppe Ruello

1. Information

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

XXXII 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:

- ✓ Tomografia e imaging: principi, algoritmi e metodi numerici (9 cfu)
- ✓ Elaborazione Numerica dei Segnali (6 cfu)

and I have attended the following seminars:

- ✓ Convolutional Neural Networks - Application to Remote Sensing
- ✓ IBM Q: Building the first universal quantum computers for business and science
- ✓ Tailoring Waves at the Extreme with Metamaterials
- ✓ Uso del cellulare e tumori cerebrali: Le evidenze epidemiologiche
- ✓ Malattie Professionali da campi elettromagnetici tra scienza e giustizia
- ✓ Lo sviluppo e la gestione della proprietà intellettuale: Da un caso reale agli aspetti generali
- ✓ How to publish a scientific paper
- ✓ Il 5G e l'evoluzione delle reti radiomobili
- ✓ Filtraggio dell'azimuth ambiguity in Immagini SAR

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

	Credits year 1								Credits year 2								Credits year 3									
	Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth	5 bimonth	6 bimonth	Summary	Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth	5 bimonth	6 bimonth	Summary	Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth	5 bimonth	6 bimonth	Summary	Total	Check
Modules	18	0	0	6	0	3	12	**21**	9	0	0	0	0	0	0	**0**	9	0	0	0	0	0	0	**0**	21	30-70
Seminars	13	0.8	0	1.3	0	2	1.1	**5.2**	6	0	0	0	0	0	0	**0**	6	0	0	0	0	0	0	**0**	5.2	10-30
Research	34	9.2	10	2.7	10	5.1	3	**40**	42	0	0	0	0	0	0	**0**	42	0	0	0	0	0	0	**0**	40	80-140
	65	10	10	10	10	10.1	16.1	**66.2**	57	0	0	0	0	0	0	**0**	57	0	0	0	0	0	0	**0**	66.2	180

3. Research activity

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

a. Deep Learning approaches in Remote Sensing Applications
b. 5G Channel Modeling in urban environment

Here I briefly explain each of which:

a. 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:
1) Single-sensor data fusion for RS super-resolution;
2) Multi-sensor data fusion for NDVI regression;
3) 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:
(i) the use of the residual learning strategy,
(ii) the batch normalization, both (i) and (ii) aimed to speed-up the learning,
(iii) a high-pass preprocessing of the input, and, finally,
(iv) the extension to all 20-m bands.
In the research activity 2), based on the idea that the Sentinel 2 bands are not available under cloudy conditions, a possible alternative is to resort to synthetic aperture radar (SAR) images. However, many conventional Earth monitoring applications require specific spectral features which are defined only for multispectral data. Motivated by this consideration, I have proposed to estimate missing spectral features through data fusion and deep learning, exploiting both temporal and cross-sensor dependencies on Sentinel-1 and Sentinel-2 time-series.
In the research activity 3), 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 fed the CNN. To begin the CNN optimization algorithm I have considered a water map and rice map from 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, XinghaoDing, and John Paisley, "Pannet: A deep network architecturefor 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, Jośe 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 pro-duced 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, andCP 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:

"A CNN-Based Fusion Method for Feature Extraction from Sentinel Data" submitted on Remote Sensing

"A CNN-Based Fusion Method for Super-Resolution of Sentinel-2 Data" submitted on IGARSS 2018

"Estimating the NDVI from SAR by Convolutional Neural Networks" submitted on IGARSS 2018

Waiting for approval:

"Advances on CNN-based Super Resolution of Sentinel-2 Images" submitted on IGARSS 2019

5. Conferences and Seminars

I have taken part at the following conference/seminar:

   a. International Geoscience and Remote Sensing Symposium '18
   b. 8th Advanced Training Course on Land Remote Sensing
   c. 5G International PhD School

6. Activity abroad

I have spent three months abroad at the CIRAD, Montpellier, France.

7. Tutorship

I have not given lectures in *any course.*