Massimiliano Gargiulo

Tutor: Prof. Giuseppe Ruello

XXXIII Cycle - I year presentation

“Deep Learning for Remote Sensing”

Università degli Studi di Napoli Federico II

Background

M. Sc.	Ph.D.
Telecommunication Engineering – October 26th 2017	**Department of Electrical Engineering and Information Technology**, building 2, Via Claudio.
Subject: **Deep Learning** Prof. ***Giuseppe Scarpa***	**ING-INF/02**
Title: ***Pansharpening for MNDWI estimation using CNN***	Prof. **Giuseppe Ruello**

Collaborations

CIRAD Ing. Raffaele Gaetano(Ph.D.)	
Università degli Studi di Napoli Federico II Prof. Giuseppe Scarpa (Ph.D.) Ing. Antonio Mazza (Ph.D. Student)	
Università degli Studi di Salerno Prof. Maria Nicolina Papa (Ph.D.)	

The limitations of satellite remote sensing

Optical (Sentinel-2)

SAR (Sentinel-1)

Cloudy Sensitivity

Spatial Resolution

Difficult to manage

Deep Learning

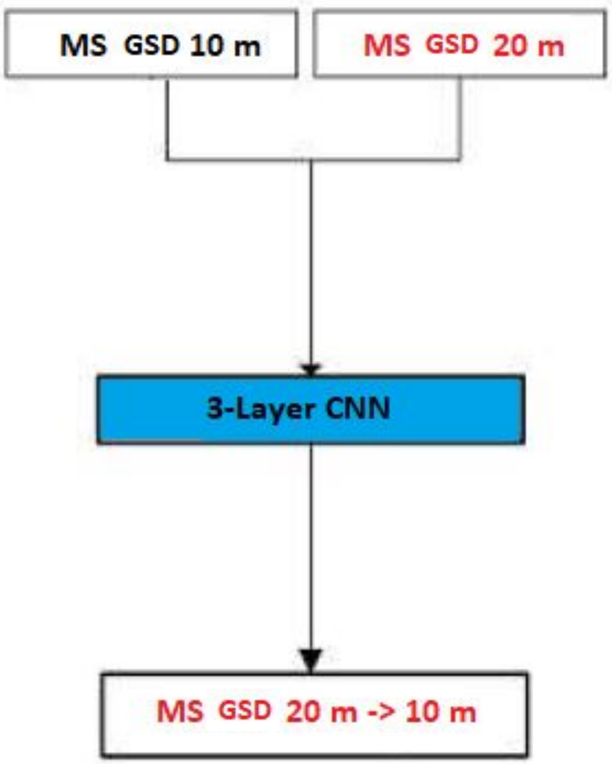
Single-sensor data fusion

Image Classification Techniques

Multi-sensor data fusion

Main Topic:
Super Resolution

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).



Advances on Super Resolution

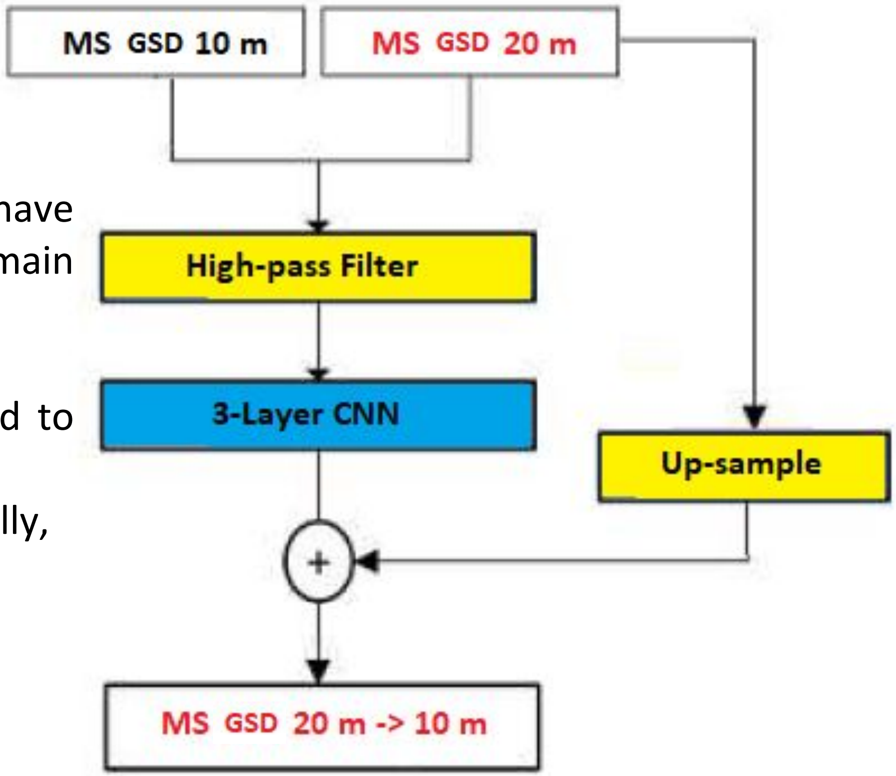
Therefore, encouraged by very promising results I have considered an improved version with four main integrations:

(i) the use of the residual learning strategy,

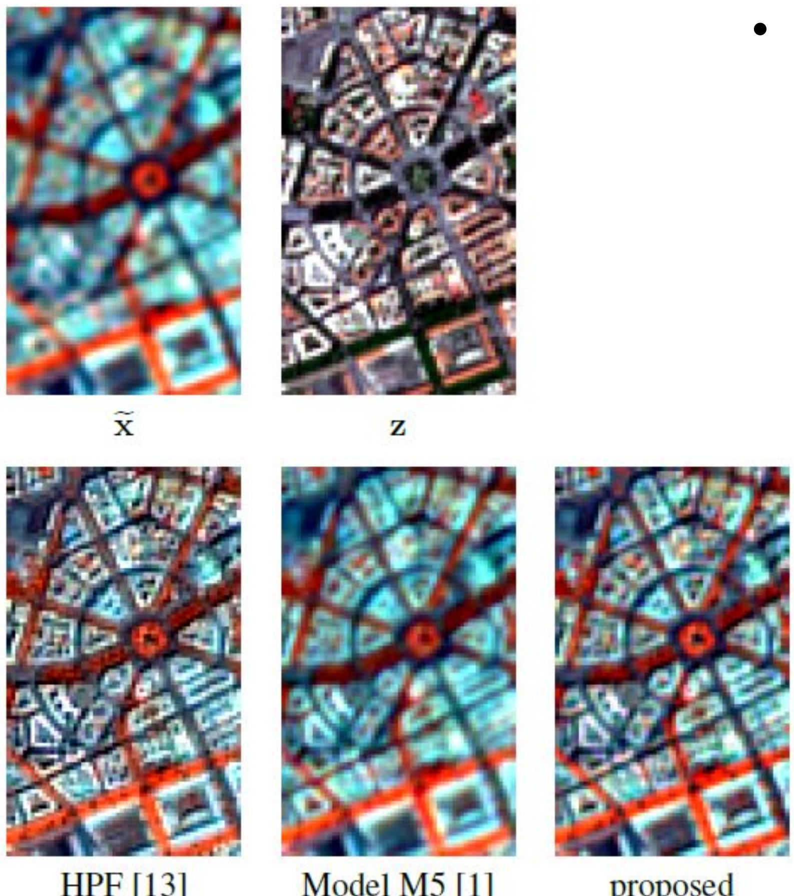
(ii) the batch normalization, both (i) and (ii) aimed to speed-up the learning,

(iii) a high-pass preprocessing of the input, and, finally,

(iv) the extension to all 20-m bands.

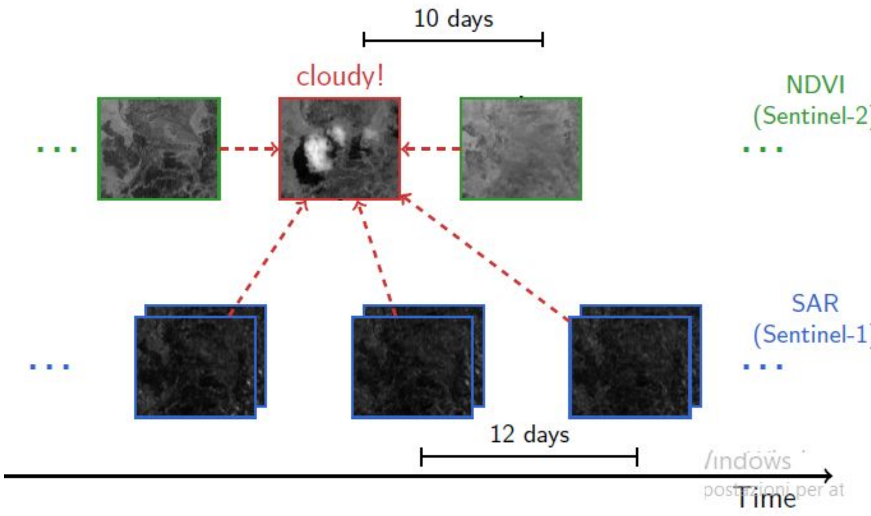


Visual Inspection at full-resolution



- Publication of two **conference paper**:
  - *M. Gargiulo, A. Mazza, R. Gaetano, G. Ruello, and G. Scarpa, "A CNN-based fusion method for super-resolution of Sentinel-2 data," in IGARSS 2018 - 2018 IEEE International Geoscience and Remote Sensing Symposium, July 2018, pp. 4713–4716.*
  - *A. Mazza, M. Gargiulo, G. Scarpa, and R. Gaetano, "Estimating the ndvi from sar by convolutional neural networks," in IGARSS 2018-2018 IEEE International Geoscience and Remote Sensing Symposium. IEEE,2018, pp. 1954–1957.*

NDVI regression

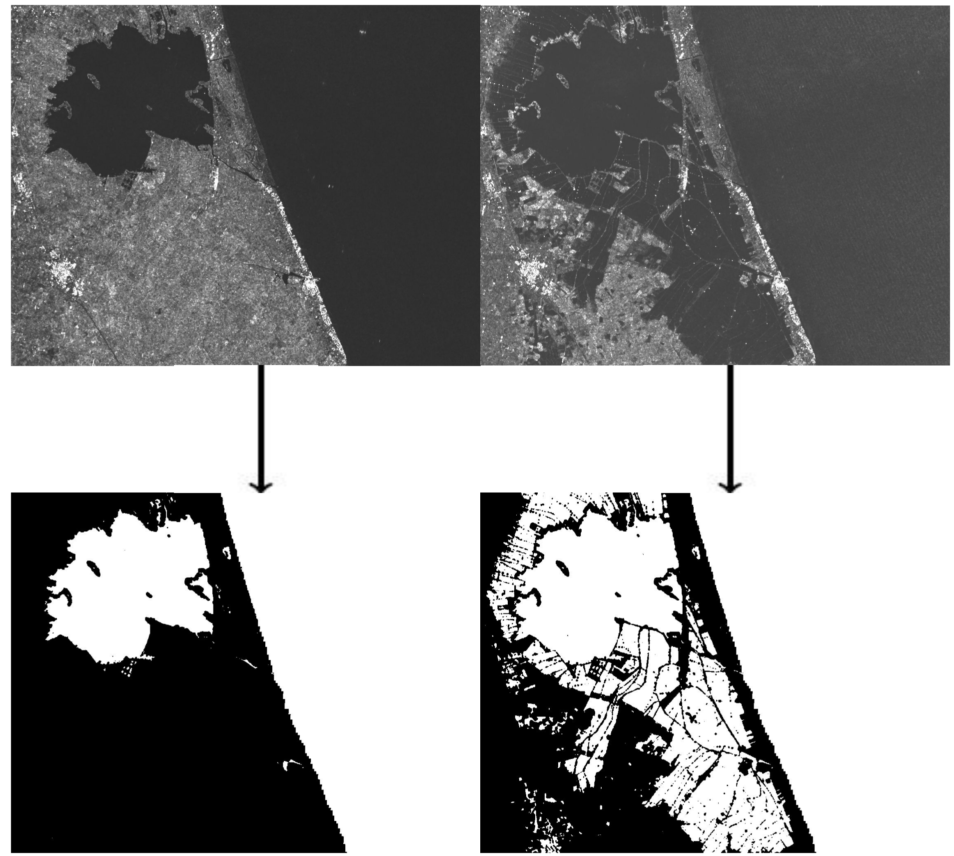


In the research activity 2), based on the idea that the Sentinel 2 bands are not available under cloudy conditions, a possible alternative is to resort to synthetic aperture radar (SAR) images. However, many conventional Earth monitoring applications require specific spectral features which are defined 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.

- Publication of **journal paper**:
  - *G. Scarpa, M. Gargiulo, A. Mazza, and R. Gaetano, "A CNN-Based Fusion Method for Feature Extraction from Sentinel Data," Remote Sensing, vol. 10, no. 2, pp. 236, 2018.*

Rice/Water Classification

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.

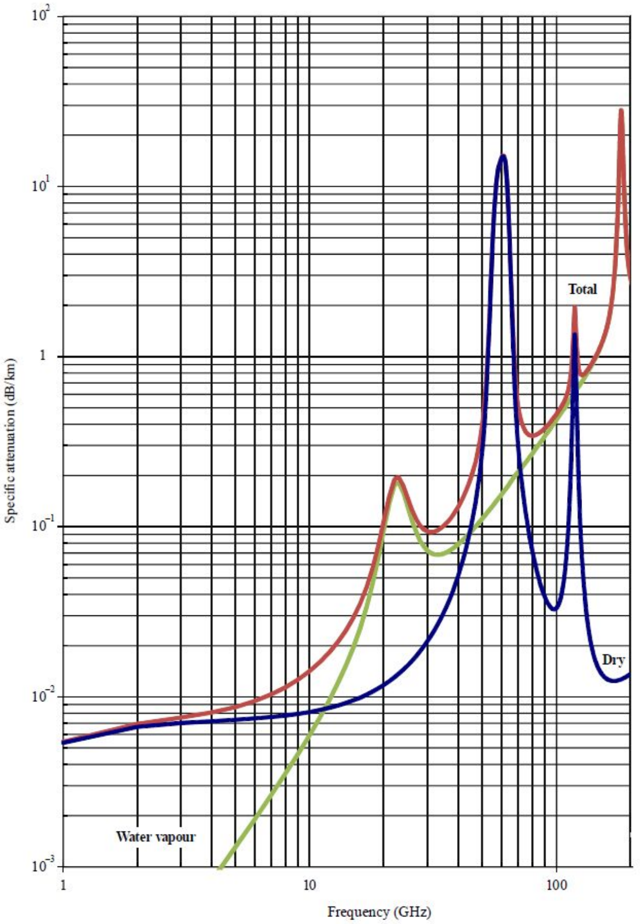


Additional Topic:
5G Channel Modeling

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.

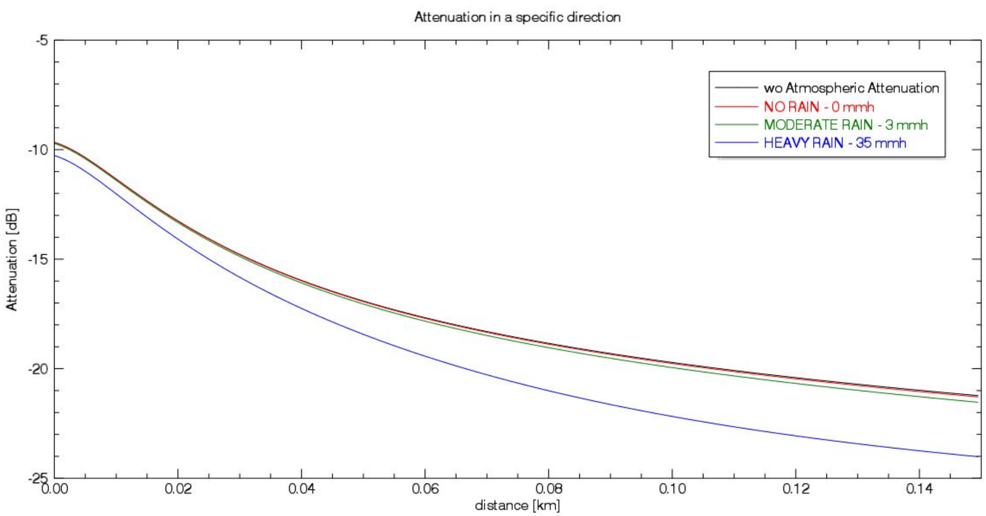
However, the bottleneck of the use of such high frequencies is related to **attenuation and penetration through buildings** to allow outdoor-indoor communications.

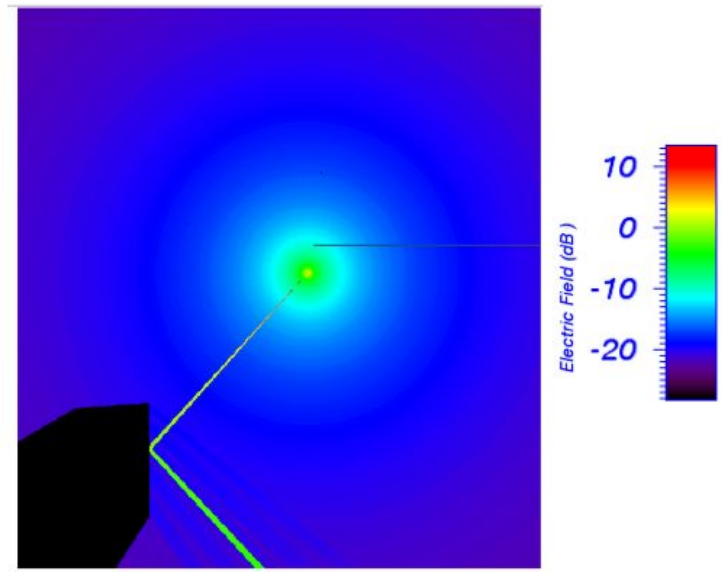
Therefore, it is important to provide a complete **characterization of the wireless channel** to above-mentioned transmission frequencies.



Simulations for Atmospheric Attenuation Modeling

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.

First year production

- Publication of **journal paper**:
  - *G. Scarpa, M. Gargiulo, A. Mazza, and R. Gaetano, “A CNN-Based Fusion Method for Feature Extraction from Sentinel Data,” Remote Sensing, vol. 10, no. 2, pp. 236, 2018.*
- Publication of two **conference paper** and one is waiting for approval:
  - *M. Gargiulo, A. Mazza, R. Gaetano, G. Ruello, and G. Scarpa, “A CNN-based fusion method for super-resolution of Sentinel-2 data,” in IGARSS 2018 - 2018 IEEE International Geoscience and Remote Sensing Symposium, July 2018, pp. 4713–4716.*
  - *A. Mazza, M. Gargiulo, G. Scarpa, and R. Gaetano, “Estimating the ndvi from sar by convolutional neural networks,” in IGARSS 2018-2018 IEEE International Geoscience and Remote Sensing Symposium. IEEE,2018, pp. 1954–1957.*
  - *M.Gargiulo, “Advances on CNN-Based Super-Resolution of Sentinel-2 Images” in IGARSS 2019-2019 IEEE International Geoscience and Remote Sensing Symposium. IEEE,2019 (Waiting for Approval)*

First year credits

Cycle XXXIII	Credits year 1							
	Estimated	bimonth 1	bimonth 2	bimonth 3	bimonth 4	bimonth 5	bimonth 6	Summary
Modules	18	0	0	6	0	3	12	21
Seminars	13	0.8	0	1.3	0	2	1.1	5.2
Research	34	9.2	10	2.7	10	5.1	3	40
	65	10	10	10	10	10.1	16.1	66.2

Student: Massimiliano Gargiulo
massimiliano.gargiulo@unina.it

Tutor: Giuseppe Ruello
giuseppe.ruello@unina.it

- **Conferences and PhD schools:**
  - International Geoscience and Remote Sensing Symposium ‘18
  - V Convegno Nazionale “Interazioni tra Campi Elettromagnetici e Biosistemi”
  - 8th Advanced Training Course on Land Remote Sensing
  - 5G International PhD School

Next years

- **Research activity:**

  - Of a particular interest it would be the collection of a much larger training dataset that would enable to reliably train much deeper networks. Eventually, the design of a novel framework for RS images interpretation is required, in instance in classification task.

  - First of all, validation of 5G Channel Modeling comparing with main works on 5G content and/or with massive measurement campaigns. This step is fundamental to establish the effectiveness of the model and the software. Eventually, dimensioning and optimization of 5G Wireless Communication Networks.

Credits summary

	Credits year 1								Credits year 2								Credits year 3									
	Estimated	bimonth 1	bimonth 2	bimonth 3	bimonth 4	bimonth 5	bimonth 6	Summary	Estimated	bimonth 1	bimonth 2	bimonth 3	bimonth 4	bimonth 5	bimonth 6	Summary	Estimated	bimonth 1	bimonth 2	bimonth 3	bimonth 4	bimonth 5	bimonth 6	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