Matteo Ciotola

Deep learning for data fusion in remote sensing and beyond

Tutor: Giuseppe Scarpa

Cycle: XXXVI   Year: First

My background

- MSc in Automation Engineering – Università degli Studi di Napoli Federico II

- Research group: GRIP

- PhD start date: 11/1/2020

- Scholarship type: UniNA

# Research field of interest

- Objective: development of Pansharpening and Super-Resolution algorithms in a deep-learning and data fusion framework

- Importance of super-resolved data: a high-definition multispectral data improve the accuracy of soil classification and may be used in several application such as land monitoring, agricultural, climate change analysis, defense

- Data fusion thanks to the exploit of some bands with a high spatial and low spectral definitions and other bands with low spatial and high spectral definitions

Pansharpening
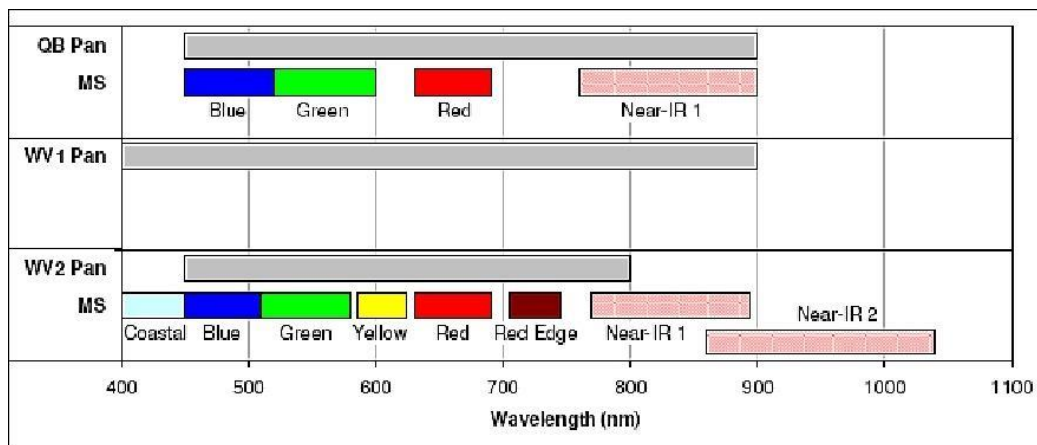
Super-Resolution

Source: http://esamultimedia.esa.int/docs/EarthObservation/Sentinel-2_ESA_Bulletin161.pdf
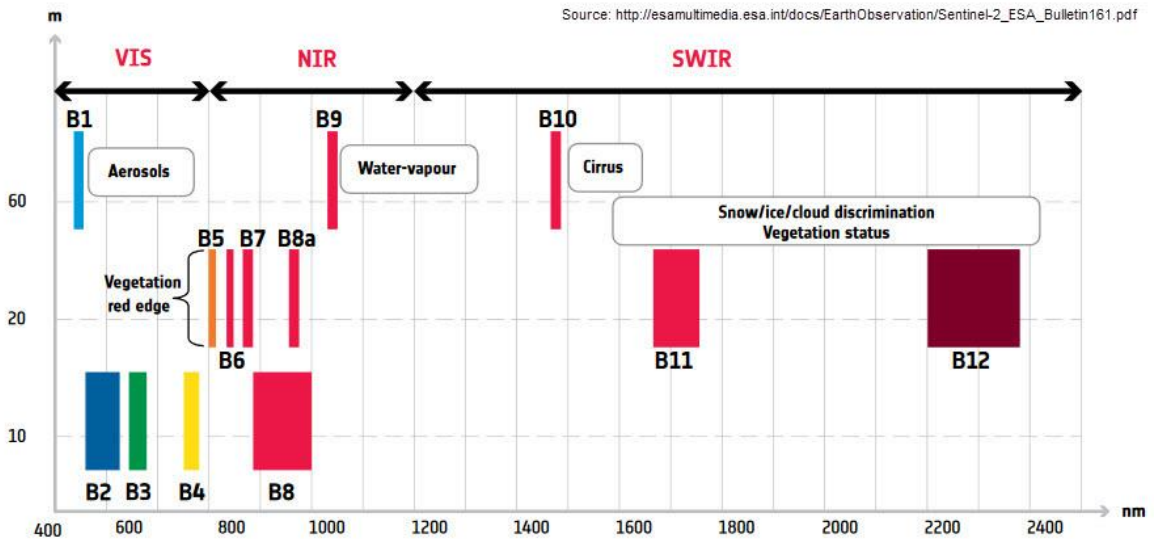
Summary of study activities

- **PhD School**: "2021 IEEE - EURASIP Summer School on Signal Processing (S3P-2021) - Signal Processing for human-machine communication and interaction (SP-HMCI)", **Lecturers:** Prof. Patrizio Campisi, Prof. Emanuele Maiorana; The school has given an overview of the state of the art on the most advanced signal processing techniques relevant for human-computer communication and interaction (HCMI).

- **PhD courses:** "Modeling Complex System", **Lecturer:** Prof. Mario Di Bernardo; The course has been centred on the modelling, analysing and controlling complex systems., through a system and control approach.

- **M. Sc. Courses:**

  1. "Elaborazione dei Segnali Multimediali", **Lecturers:** Prof.ssa Luisa Verdoliva, Prof. Davide Cozzolino; The course has dealt with the main techniques for elaboration and encoding of images and videos. In particular, the central topics have been the enhancement and restoration of images and the standards for the compression of images and videos

  2. "Elaborazione Numerica dei Segnali", **Lecturer**: Prof. Giuseppe Scarpa; The course has been centred on the analysis and elaboration of signals in the frequency domain, both for analogic and digital data. Meticulous attention has been spent on FIR and IIR filters, and how to exploit them with image elaboration

- **Conference:** "IEEE International Geoscience and Remote Sensing Symposium - IGARSS 2021" Virtual Conference, July 12-16, 2021

Research activity: Overview

- Pansharpening and super-resolution are both two techniques of remote sensing images enhancement. These techniques are used for several applications, such as defence, agricultural, environmental defence;

- The goal is a definition of a framework to improve the definition of multispectral bands

- The main difficulty is the lack of ground truth with which evaluate the goodness of algorithms
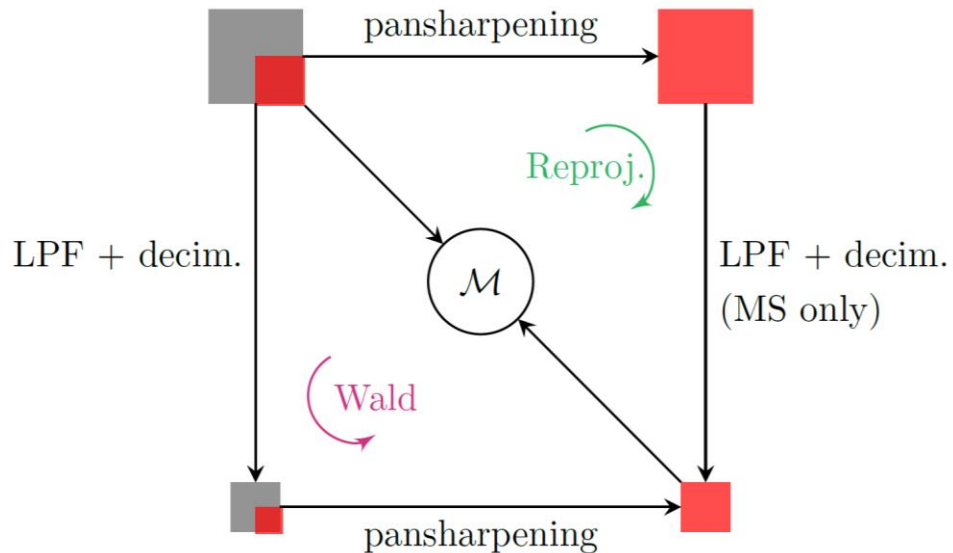
Research activity during the First Year

- Study of State-of-Art of Pansharpening and Super-resolution methods
- Study on Deep-Learning techniques and the principal loss functions developed for supervised deep learning Pansharpening and super-resolution frameworks
- Development of an unsupervised deep learning approach for Pansharpening and Super-Resolution
- Testing of the full-resolution framework on several satellites, such as WorldView-2, WorldView-3, GeoEye-1 (for Pansharpening) and Sentinel-2 (for Super-Resolution)
- Study on main evaluation indexes, both with and without reference
- Proposal of new indexes for Pansharpening evaluation

PAN

MS

A-PNN-FT

Proposed*

PanNet

*M. Ciotola, S. Vitale, A. Mazza, G. Poggi, G. Scarpa – "*Pansharpening by convolutional neural network in the full resolution framework*" – IEEE Transaction on Geoscience and Remote Sensing

Intended Contributions

- Adaptation of the full-resolution deep-learning technique to other satellites
- Refine of loss functions, for a more computational efficiency
- Definition of new no-reference evaluation metrics (open issue)
- Definition of a cross sensor algorithm, to enhance even more spatial definition of raw data
- Attempts of improvement of actual algorithm, exploiting new deep-learning trends, as GAN, Perceptual loss, self attention mechanism, etc.

Products

[J1]	M. Ciotola, S. Vitale, A. Mazza, G. Poggi, G. Scarpa – "*Pansharpening by convolutional neural network in the full resolution framework*" – IEEE Transaction on Geoscience and Remote Sensing
[P1]	G. Scarpa, M. Ciotola – "Full-resolution quality assessment for pansharpening" -- arXiv:2108.06144, 2021
[C1]	M. Ciotola, M. Ragosta, G. Poggi, G. Scarpa – "*A full-resolution training framework for Sentinel-2 image fusion*" – IEEE International Geoscience and Remote Sensing Symposium (IGARSS) 2021, pp.1260-1263

Thank you for the attention!

itee PhD
information technology
electrical engineering