Data fusion with machine learning

SUMMARY.

Current space missions, benefiting from technological progresses, have raised the amount of collected data to unprecedented levels, and have highlighted a critical need for the development of new tools capable of processing and analysing big data from space. Artificial Intelligence (AI) is a powerful tool that is becoming more common across a wide range of fields, including astronomy and Earth observations. In this module, the student will use AI techniques for data fusion, which consists in combining data from different sensors or missions to produce an enhanced data product. This module is provided by ACRI-ST, an SME of the space sector that provides engineering and data services for space missions.

OBJECTIVES

- The student will learn about AI techniques (Neural networks, Fusformer), understand their advantages and limitations.
- The student will learn to run machine learning models, as well as use Earth observations or JWST data).

PREREQUISITES

- ☒ S1. Data Sciences
- ☒ S1. Numerical methods
- ☒ S2. Statistics

It is recommended to have good coding skills in python. Familiarity with machine learning is also beneficial.

THEORY

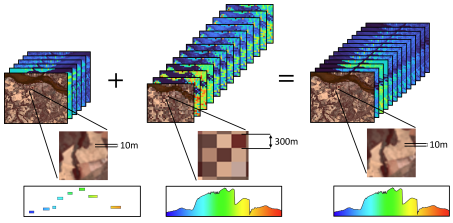
by Nick Cox

The module will cover basic aspects of supervised, semi-supervised and unsupervised learning, as well machine learning (Random forest), deep learning (CNN and auto-encoders).

APPLICATIONS

by Pierre-Laurent Cristille

Data fusion is a key challenge in the current multi-messenger era. By fusing data, it is possible to overcome limitations of individual measurements, improving the overall quality and completeness of the information. The student will apply transformer-based networks to improve data products from the Sentinel missions of the European Copernicus programme or the James Webb Space Telescope. The project covers different steps in data science, from data preparation, model fitting (train/test), hyperparameter optimisation, and data analysis and interpretation.



Data fusion concept

MAIN PROGRESSION STEPS

There module is divided in three main stages as described below:

- `Week 1`: Focuses on AI and thematic courses.
- `Week 2-5`: Model implementation and first results
- `Week 6-7`: Model refinement, project report and presentation

EVALUATION

- `Theory grade [30%]`
  - Written Report (70%): bibliography, thematic and technical description
  - Project Presentation (30%): questions
- `Practice grade [30%]`
  - Progress meetings (30%): progress
  - Project report and presentation (70%): initiative, analysis, results
- `Defense grade [40%]`
  - Oral and slides quality
  - Context
  - Project / Personal work
  - Answers to questions

BIBLIOGRAPHY & RESOURCES

The links below provide information on basic machine learning and on the methodology at the core of the module.

- Machine learning in python
- Machine learning and data mining for astronomy
- Fusformer for super-resolution and data fusion

Image credits: Title (NASA, ESA, Hubble Legacy Archive, Utkarsh Mishra). Data fusion: P-L. Cristille (Remote Sensing, 2024)

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