Exoplanet Detection using AI

SUMMARY.
The era of Big Data is transforming the way scientists approach their research, and ultimately how science progresses and discoveries are made. Current space missions have highlighted a critical need for the development of new tools capable of processing and analysing Big Data from space. In parallel, recent missions, benefiting from technological progresses, have raised the level of collected data to unprecedented levels. Advances in observation systems and instruments require equal advances in data management and analysis. In this framework, 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 to detect exoplanets using observations from the VLT. This module is provided by ACRI-ST, an SME of the space sector that provides engineering data services for space missions.

OBJECTIVES

The module will provide practical algorithmic knowledge. The student will become familiar with different AI techniques, including deep learning using neural networks.

Understanding of the problematic, and how to tackle it, will enable the student to develop critical thinking and a creative mindset.

PREREQUISITES

Some knowledge of the programming language Python and general computing skills are required. Having followed courses on Maths/Stat, Signal/image processing and General Astrophysics are encouraged.

THEORY

by Nick Cox

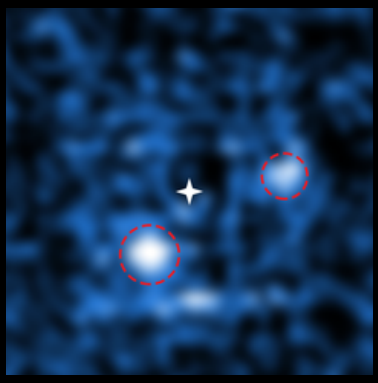
The module will cover:

- Supervised, semi-supervised and unsupervised learning
- Machine learning (e.g. Random Forests) and Deep learning (e.g. Convolutional Neural Networks, Auto-Encoders)

APPLICATIONS

by Jeronimo Bernard-Salas / Anthony Salsi

The student will apply convlutional neural networks for the detection of exoplanets using observations from the SPHERE instrument in the Very Large Telescope (VLT). The goal is to use deep learning to improve the detection exoplanets from direct imaging. The project will cover different steps in data science, from data preparation, pre-processing, and model fitting (train/test), hyperparameters optimisation, data analysis and scientific interpretation.



MAIN PROGRESSION STEPS

- First half-week: theoretical courses (a series of talks with exercises in between).
- Practical period (6 weeks): Applied AI astrophysics project.
- Last week: Preparation of final project presentation and report.

EVALUATION

ACRI-ST grading:

- Theoretical understanding of applied AI techniques (weight 50%)
- Practical evalution of written report, research quality and professional development (weight 50%)

BIBLIOGRAPHY & RESOURCES

Machine Learning in Python
Machine Learning and Data Mining for Astronomy
Direct Imaging and Spectrsocopy of Extrasolar Planets
Variational Auto-Encorders
Image credits: S106 (NASA, ESA, Hubble Legacy Archive, Utkarsh Mishra). Exoplanet image: ESO and S. Haffert (Leiden Observatory.

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