Introduction to Machine Learning in Astronomy

SUMMARY.

Machine learning has been sweeping the world over the past 15 years. The revolution brought about by these new techniques has considerable ramifications across astronomy, bringing spectacular new results over a large range of applications. With the relentless growth of the volume of data in the years to come, these methods are set to develop even more and the revolution is certainly only beginning. In this METEOR we will take the first steps into this new world and learn of different machine learning techniques and how to use them to answer our questions about the universe.

OBJECTIVES

First and foremost, the students will become familiar with different machine learning algorithms, which they will implement themselves or use through specialized public libraries. They will learn to identify which problems are best addressed by such techniques, clearly identifying the benefits and drawbacks with respect to more classical approaches in order to make an informed decision. They will also be able to select the most appropriate machine learning algorithm to address a specific question. Finally, they will learn how to adapt and apply such algorithms to astronomical cases.

PREREQUISITES

It is mandatory to have followed the Mathematical and Statistical Methods course. A working knowledge of Python is needed.

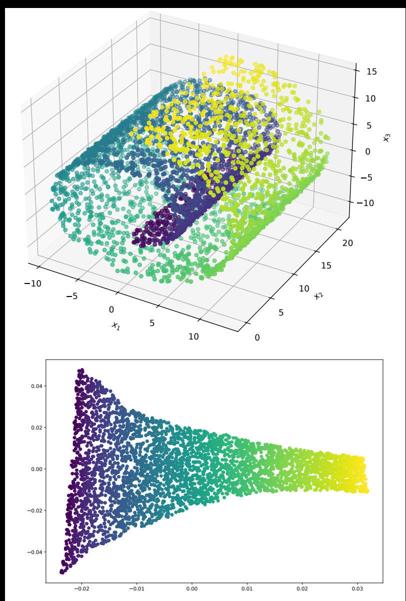
THEORY

by Médéric Boquien

This METEOR will cover the following topics: support vector machines, decision trees, ensemble learning and random forests, dimensionality reduction, and clustering.

APPLICATIONS

by Médéric Boquien



The students will apply machine learning algorithms to real astronomical cases based on models or large surveys such as Gaia or SDSS. This will include for instance automated object classification or the detection or rare objects in large catalogs. The students will analyze their results critically, comparing them with those published in the literature. Finally, they will infer what these results tell us about the universe.

MAIN PROGRESSION STEPS

The first week will be dedicated to an overview of the field of machine learning in astronomy and an introduction to the project topics, which will be selected by the end of the second week. Theoretical courses will follow and the project will be carried out in parallel until the last week, which will focus on the preparation of the oral presentations.

EVALUATION

Five oral presentations on different machine learning algorithms (30%). Written report on the project with an important emphasis of the critical analysis of the results and what they tell us about the universe (30%). Final oral presentation (40%).

BIBLIOGRAPHY & RESSOURCES

- Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 3rd Edition, Géron (2022)
- Statistics, Data Mining, and Machine Learning in Astronomy, Ivezić et al. (2019)

CONTACT

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