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Machine Learning Solutions for Data Analysis and Exploitation in Planetary Science - A Work Package in Europlanet 2024 Research Infrastructure

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Funded through the European Commission's Horizon 2020 programme, Europlanet 2024 Research Infrastructure (RI) provides free access to planetary simulation and analysis facilities, data services and tools, a ground-based observational network and programme of community support activities. The University of Kent, UK, leads the Europlanet 2024 RI consortium, which has 57 beneficiary institutions from 25 countries in Europe and around the world, with a further 44 affiliated partners. The work package "Machine Learning Solutions for Data Analysis and Exploitation in Planetary Science" develops ML powered data analysis and exploitation tools optimized for planetary science and integrates expert knowledge on ML into the planetary community. We give an overview of our work package and ML activities within Europlanet 2024 RI.

OBJECTIVES

The main objectives of the machine learning work package are:

- To develop machine learning (ML) tools, designed for and tested on planetary science cases submitted by the community, and to provide sustainable, open access to the resulting products, together with support documentation.
- To foster wider use of ML technologies in data driven space research, demonstrate ML capabilities and generate a wider discussion on further possible applications of ML.

The goal is to build a multipurpose toolset for ML-based data analysis that will be applicable to a range of scientific research questions in planetary science with minor or easily-achievable customization efforts. We provide both, trained models as well as ML code, all of which are free to use and can be adapted by the user. The term "ML tool" refers in our case to ML codes, notebooks, or trained models, with which data can be analyzed. Applying our tools to data will result in (high-level and derived) data products, which will be made available via VESPA (Virtual European Solar and Planetary Access; `http://vespa.obspm.fr`), together with the original data.

The tools are shared and made accessible to the wider planetary science community through a webpage, the ML Portal, and our GitHub organization. The ML work package also provides documentation, tutorials, and workhops, to support the beneficiaries and the community users of the ML tools.

SCIENCE CASES

During the proposal phase of this project, the scientific community was asked to propose scientific use cases that should be tackled with ML approaches in our work package. Out of these proposed cases, a representative set of science cases was selected and the respective institutes were included as beneficiaries (see Tables 1 and 2).

Proposer	Science Case
AOP	Abundance of asteroids in Earth-like orbits from STEREO images
DLR	Classification of surface composition on the surface of Mercury
IAP-CAS	Detection of plasma boundary crossings at planetary magnetospheres and in the solar wind
	Classification of plasma wave emissions in electromagnetic spectra
INAF	Mineral identification via reflectance spectra
IWF-OEAW	Detection and classification of CMEs and CIRs in in-situ solar wind data
LMSU	Detection of magnetopause/bow shock crossings around Mercury in MESSENGER data
GMAP[1]	Automatic recognition and analysis of planetary surface features on Mars (e.g. mounds or pits)

Table 1: List of science cases. [1]GMAP is another work package within Europlanet 2024 RI.

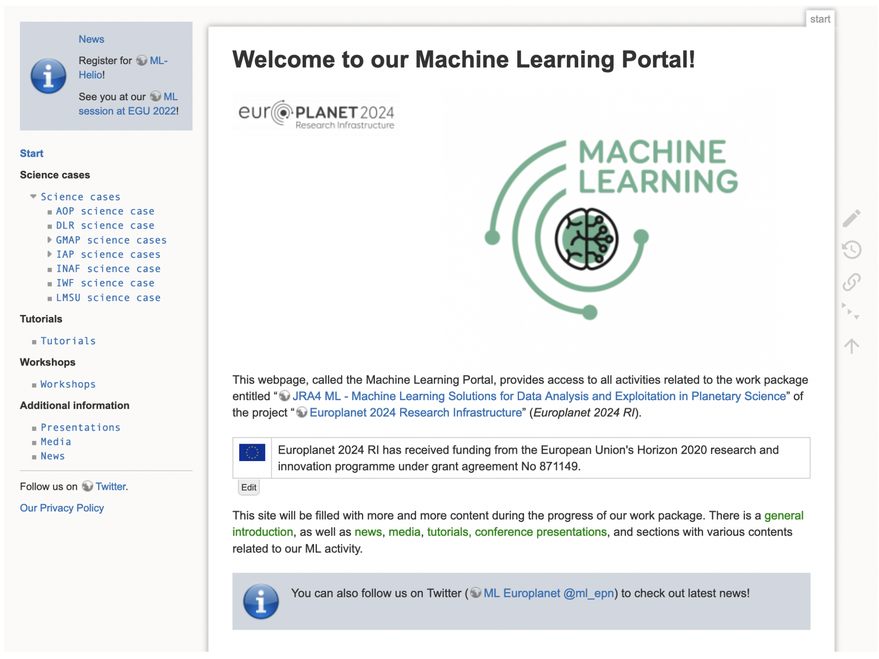
ACRI-ST	ACRI-ST, France
AOP	Armagh Observatory and Planetarium, Ireland
DLR	Deutsches Zentrum für Luft- und Raumfahrt, Germany
KNOW	Know-Center GmbH, Austria
IAP-CAS	Institute of Atmospheric Physics, Academy of Sciences of Czech Republic, Czech Republic
INAF	National Institute for Astrophysics, Italy
IWF	Space Research Institute, Austrian Academy of Sciences, Austria
LMSU	M.V. Lomonosov Moscow State University, Russia
UNIPASSAU	University of Passau, Germany

Table 2: List of beneficiaries.

The idea is that the technical partners (KNOW, UNIPASSAU, and ACRI-ST) will closely collaborate with the scientific partners of our WP to build tools that solve "real life" scientific problems and at the same time provide the flexibility necessary to adapt the resulting toolset to other related problems in planetary science with passable effort.

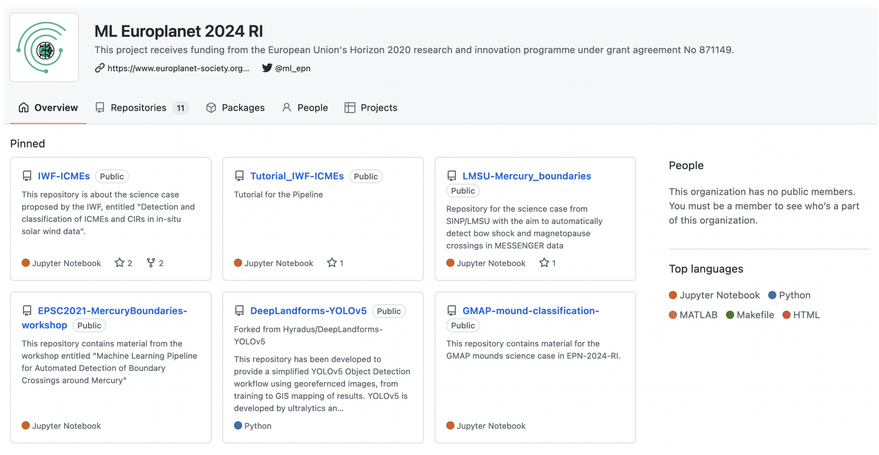
MACHINE LEARNING PORTAL

We set up a so-called **Machine Learning Portal** (ML Portal; `https://ml-portal.oeaw.ac.at`), a webpage with general information, news, tutorials, presentations, announcements, etc., about our activity.



GITHUB REPOSITORIES

Further, we have a public GitHub organization with public repositories (`https://github/epn-ml`). These repositories contain material dedicated to the science cases. There are Python code, Jupyter notebooks, saved trained models, and tutorials.



Have a look at our ML portal or at the GitHub repositories. Do not hesitate to contact us, if you have any questions or want to collaborate. Thank you!

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