EPSC Abstracts
Vol. 13, EPSC-DPS2019-1957-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Data Science Meets Planetary Science: Example Data Science Applications from the DLR Institute of Planetary Research

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Abstract

We recently have formed a Data Science working group within the DLR Institute of Planetary Research, and identified areas of research, where Data Science issues become relevant. In fact, Data Science represents an overarching activity for the various research branches of our Institute. We will present examples of our work at the conference.

Introduction

What is Data Science? We see an interdisciplinary field of methods and systems to extract and transfer knowledge or insights from data from different sources and of different types. Data Science heavily draws from mathematics, statistics, and computer science. Here, data itself are in the focus – in the light of efficient methods to handle, organize and analyze them. Data Science typically deals with large ("Big Data") and heterogeneous data sets.

While "Big Data" technologies (e.g. artificial intelligence and machine learning) have become hot topics in Earth observations in recent years, these technologies may also be beneficial to planetary science, considering the increase of data volumes being produced. In the DLR Institute of Planetary Research (with approximately 150 researchers active in diverse areas), we recently have formed a Data Science working group and identified areas of research, where Data Science issues become relevant. We consider activities not necessarily related to particular planets, particular physics, or experiments. We search for algorithms, processes, and systems, which in principle also can be applied to other science areas. Note that Data Science is not to be equated with „data processing", „data analysis", or „data modeling" (which may be important research activities, however).

More specifically, we have identified the following main Data Science topics.

Imaging science
• 3D image analysis
• Image matching
• Image understanding, semi-automated mapping, change detection

Signal- and pattern analysis (for images, time series and spectra)
• Signal and pattern detection (e.g. for detection of exoplanets)
• Feature extraction
• Uncertainty modeling
• Machine learning

Data co-registration, merging, fusion
• Automated co-registration methods
• Integration of laboratory and mission data
• Integration of data from numerical modeling (e.g. spectral modeling)
• Multi-sensor and multi-hierarchical data fusion

Modeling of physical system parameters from large and heterogeneous data sets
• Complex data inversion and adjustment problems

Structural design, implementation, management and analysis of data bases
• Planetary Information Systems
• Hierarchical databases for data fusion and detection applications

Data archiving and infrastructure (sustainable availability)

• Product development for public data archives (e.g. PDS, PSA)

Visualization and Visual Analytics
• 3D-modeling and rendering
• Experimental GIS applications (e.g. in Virtual Reality environments)
• Digital Cartography

Function approximation, classification, prediction
• Gridding algorithms (surface models from point data, spectral maps from sparse data)
• Stochastic optimization methods, evolution strategy (e.g. modeling of trajectories and orbits, characterization of exoplanets)
• Neural networks (e.g. for detection of morphological features, prediction of exo-planetary interior structures, and geodata inversion for the reconstruction of interior thermal histories)

Hence, Data Science represents an overarching activity for the various research branches of our Institute. We will present examples of our work at the conference.