Tools for supervised machine learning in Planetary Space Plasma Physics

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Introduction: Space Science is a field of study which holds huge potential for crossover with the data science community in order to make the most of the vast, rich data sets from our solar system and beyond. Data from orbiting satellites are complemented by near-continuous monitoring with ground-based instrumentation including telescopes, auroral cameras and networks of magnetometers around the globe. The Space Physics community is increasingly using tools from the fields of machine learning and data mining to maximise the scientific output from decades of observational data. However, effective use of data science techniques requires domain-specific knowledge and broad collaboration to facilitate true interdisciplinary working. In this talk I will outline some of the work of the DIAS Planetary Magnetospheres Group (dias.ie/planetary_magnetospheres) and our international collaborators. This work includes the building and curation of large labelled datasets of magnetospheric events from magnetic reconnection episodes seen in spacecraft plasma and magnetic field data [1, 2] to spacecraft crossings of magnetopause and bow shock boundaries [3, 4], to intense bursts and low frequency extentions of planetary radio emissions [5, 6]. We apply several (primarily) supervised learning approaches to classify spacecraft data. These include approaches such as Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), Feed Forward Neural Networks (FFNN), AutoEncoders, and U-Net. Furthermore we utilize specific time-series techniques (e.g. Hidden Markov Models, Matrix Profile). We show how these approaches can allow us to rapidly classify spacecraft data from missions such as Cassini at Saturn [2, 7,8, 9] and MESSENGER at Mercury [10], unlocking the full potential of these extensive datasets.

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