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High Performance Computing and Artificial Intelligence for Solar System activities at SSDC

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The Solar System exploration activities at SSDC are constantly growing and the advent of the brand new version of the MATISSE tool is going to represent the real turning point for the exploitation of powerful techniques, such as High Performance Computing (HPC) and Artificial Intelligence (AI).
Both of these two fields are currently under development using Juno-JIRAM data as test cases, with the parallelization of the atmospheric retrieval algorithm by Grassi et al. (2010, 2017) and the usage of a Computer Vision (CV –a subset of Artificial General Intelligence, AGI) system to automatically identify White Ovals in the Jupiter atmosphere.
In the first case, the SSDC team is developing a set of optimization techniques to achieve the parallel computing of existing non-parallel retrieval algorithms. A generalized library for HPC is the final objective of this activity, to be considered as an API (Application Programming Inteface) for similar science cases with SSDC involvement. The generalization is aimed both at the platform abstraction level (distributed memory model rather than shared memory model) and at the programming language level (by means of language binding into python environment and wrapping of native code).
The reference platform for development is currently the Microsoft Azure cloud, used as a suitable workbench to define, test and profile different scenarios, while the reference HPC target platform is a cluster system based on Dell technology.
In the second case cited, by means of a feature engineering phase constrained by a priori physical knowledge of the Jupiter atmosphere, nine wavelength channels were selected from the Juno-JIRAM multi-spectral imagery acquired during the Juno's first perijove as those most sensitive to changes in physical variables expected to characterize White Ovals, including cloud densities, cloud altitudes, ammonia concentration, atmospheric temperature, etc. For visualization purposes, the selected nine channels were depicted as three false-color monitor-typical RGB images showing sensory data correlated with, respectively, cloud densities, cloud altitudes and temperature-driven phenomena.
To mimic the capacity of human vision in detecting White Ovals across each of the three selected RGB images, a computational model of human vision was designed and implemented as an automated CV algorithm, requiring no human-machine interaction to run and subsequently instantiated as follows. (A) (Numeric) RGB data were submitted to color constancy and mapped by RGBIAM (RGB image automatic mapper) onto (categorical) color names. (B) Image-object shape indexes were estimated and discretized into fuzzy sets (low, medium and high). (C) Discrete and finite sets of target-specific color names and geometric fuzzy sets were logically combined by a target-specific CV decision-tree classifier.
This system, although applied preliminarily to a single data set, scored "high"in terms of outcome and process quantitative quality indexes, such as degree of automation, accuracy, efficiency and scalability.
As a future development, the CV system robustness (variance) to changes in input data will be assessed upon multiple Juno-JIRAM data acquisitions, structured according to the proposed RGB image triplets and can be also thought to be used to other type of data typically treated by SSDC, such as astronomical images or even Earth-observation ones.

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