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Artificial Intelligence at the Service of Space Astrometry: A New Way to Explore the Solar System

Advancements in artificial intelligence (AI) have opened new horizons for space exploration, particularly in the domain of astrometry. This research investigates the integration of AI techniques, specifically deep neural networks, with space astrometry using the Cassini-Huygens images database. The primary objective is to establish a robust algorithm for the detection and classification of astronomical sources, in order to process them for a better understanding of the solar system and the possible discovery of new satellites around Saturn.

The methodology employed involves a multi-step process. Firstly known stars and satellites' positions are located in the images using ARAGO, a software package designed for the astrometric measurement of natural satellite positions in images taken using the Imaging Science Subsystem (ISS) of the Cassini spacecraft. A personalised detection system, using classical image processing techniques such as mathematical morphology, is then applied to identify all the bright sources, subsequently forming a labeled database for every image including source positions, bounding boxes and corresponding classes—divided in stars, satellites, cosmic rays, and suspicious objects (which could be uncatalogued satellites or stars). The database is used to train a YOLOv5 architecture, customized for small object detection, enabling the accurate identification and classification of sources within Cassini images.

Initial analysis shows promising results, with some room for improvement due to the challenging task of detecting and classifying sources of a few pixels only.

The implications of this research are far-reaching. Spatial and temporal characterizations of cosmic rays around Saturn's magnetosphere could lead to new insights into the behavior of high-energy particles. Moreover, the detection of new small satellites orbiting Saturn holds the potential to better understand the formation and evolution of the solar system.

Beyond Saturn, the proposed methodology can be adapted to the Jupiter system using data from the upcoming JUICE mission, broadening its applicability to a wider astronomical context.

In conclusion, the fusion of artificial intelligence and space astrometry, as demonstrated in this study, introduces a promising paradigm for the exploration of the universe and in particular our solar system.

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