Development of an AI-Based Detection Pipeline for Near-Sun Comets in STEREO Imaging Data

Tuan Nguyen
Dickinson College
Mentor: Yaeji Kim, James Bauer
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The Solar TErrestrial RElations Observatory (STEREO) mission has accumulated a vast archive of heliospheric imaging data over nearly two decades, comprising millions of wide-field images obtained by the SECCHI/HI instruments [1][2]. These data provide continuous coverage of the near-Sun environment from heliocentric viewpoints inaccessible to ground-based facilities, effectively filling the gap in traditional night-side observations. Within this dataset lies largely untapped potential to identify and characterize sun-grazing comets, including dust tail formation and nucleus disruption, in the near-Sun environment. For example, recent analyses of Kreutz sun-grazing comets using STEREO data have revealed significant evolution in coma scattering cross-section and progressive fading near perihelion as well as evidence for nucleus disintegration prior to perihelion [3]. More generally, heliospheric imaging enables the study of transient phenomena such as fragmentation and tail disconnection events, while its multi-angle viewing geometries help to better constrain cometary properties. Furthermore, thousands of sungrazing comets have been discovered by sun-viewing spacecraft, including some by STEREO [4].

Despite this scientific potential, no systematic search has been conducted across the full STEREO archive to identify and characterize cometary activity. The scale of the dataset, spanning over a decade of continuous observations with a high time cadence of approximately 40 minutes, makes manual inspection infeasible and motivates the development of automated approaches. In this project, we develop an AI-based detection pipeline to autonomously identify comet-like features in STEREO images. The pipeline leverages calibrated image products from a collaboration with the Korea Astronomy and Space Science Institute and uses advanced difference imaging techniques to effectively isolate moving objects from background stars. Machine learning techniques, including convolutional neural networks and classical feature-based classifiers, are applied to distinguish faint, extended cometary structures from complex solar background features and instrumental artifacts [5]. The resulting system will enable systematic extraction of comet candidates and activity signatures from the full STEREO dataset, providing a new resource for studying near-Sun comet populations.

References

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