A Novel Computer Vision Approach to Radial Velocity Extraction for Exoplanet Detection

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Studying the Radial Velocity (RV) of stars led to the first definitive detection of an exoplanet in 1995 and has since contributed to the discovery of several thousand exoplanets. Cross-correlating spectral data with a template mask has been the standard approach to RV extraction. In the last decade, scientists have been actively seeking enhanced RV extraction techniques to boost precision, simplify procedures, and reduce the overall computational workload. In this proof-of-concept research, we present a novel approach that utilizes computer vision (CV) techniques to analyze stellar spectra and accurately extract RVs. We first constructed 2D spectral line images from the raw stellar data and devised several enhancement approaches to make the images more suitable for feature detection. We then applied CV techniques to detect, match, and transform features between two images. We successfully extracted RV information using this novel method. We tested our method on four real stellar data sets measured by the Yale Extreme-precision Spectrograph Stellar Signals Project (ESSP). We found that it yields results comparable to an industry-standard method in both time and frequency domains. From the sensitivity test outcomes, it is evident that the CV method exhibits a high level of robustness against diverse model settings and can effectively handle potential measurement noise. Its fast speed in RV extraction also positions it among the fastest methods available. This novel computer vision-based RV extraction technique, combined with advancements in instrumentation, could push the RV extraction resolution further below the 1 m/s level to identify star-exoplanet systems similar to our Sun-Earth and eventually discover real habitable exoplanets.

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