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Discovery of Exoplanets in Kepler Data Using a Graphics Processing Unit Fast Folding Method and a Deep Learning Model

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Abstract : Kepler has discovered over 4000 exoplanets and candidates. However, current transit planet detection techniques based on the wavelet analysis and the Box Least Squares (BLS) algorithm have limited sensitivity in detecting minor planets with a low signal-to-noise ratio (SNR) and long periods with only 3-4 repeated signals over the mission lifetime of 4 years. This paper presents a novel precise-period transit signal detection methodology based on a new Graphics Processing Unit (GPU) Fast Folding algorithm in conjunction with a Convolutional Neural Network (CNN) to detect low SNR and/or long-period transit planet signals. A comparison with BLS is conducted on both simulated light curves and real data, demonstrating that the new method has higher speed, sensitivity, and reliability. For instance, the new system can detect transits with SNR as low as three while the performance of BLS drops off quickly around SNR of 7. Meanwhile, the GPU Fast Folding method folds light curves 25 times faster than BLS, a significant gain that allows exoplanet detection to occur at unprecedented period precision. This new method has been tested with all known transit signals with 100% confirmation. In addition, this new method has been successfully applied to the Kepler of Interest (KOI) data and identified a few new Earth-sized Ultra-short period (USP) exoplanet candidates and habitable planet candidates. The results highlight the promise for GPU Fast Folding as a replacement to the traditional BLS algorithm for finding small and/or long-period habitable and Earth-sized planet candidates in-transit data taken with Kepler and other space transit missions such as TESS(Transiting Exoplanet Survey Satellite) and PLATO(PLAnetary Transits and Oscillations of stars).

Keywords : algorithms, astronomy data analysis, deep learning, exoplanet detection methods, small planets, habitable planets, transit photometry
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