MACHINE LEARNING FOR ASTROPHYSICS
2ND EDITION CATANIA, 8-12 JULY, 2024

Contribution ID: **240** Type: **not specified**

LightPred - a deep learning model for stellar properties predictions

Wednesday 10 July 2024 11:15 (5 minutes)

Stellar properties play an important role in understanding the evolution of stars, galaxies, and planetary systems. for example, stellar period is essential for understanding stars' age and stellar inclination is important for understanding planetary formation and dynamics. Despite their importance, it is not trivial to measure most of the stellar properties. On the other hand, since the release of "Kepler" mission there has been vast amount of lightcurves for a large sample of stars which opens the door for data-driven analysis. The inference of period and inclination from lightcurves is based on the change in observed flux due to starspots and in general is a challenging task. The period of star can be affected by other periodicities in the system (the spots emergence rate for example) and can change across different latitudes (differential rotation). The most common technics in analyzing period are autocorrelation function and wavelet transform, and recently Reinhold et al reported the largest sample of period calculations from Kepler data (67139 stars) using both methods. The inclination measurements are much more challenging and degenerate with the spot's latitude (As pointed out by Walckovich, Basri and Valenti in 2013). The common methods to calculate inclinations are Rossiter-maclughling effects and Asterosysmology but both can be applied only on a very small subset of, usually planet hosting, stars. In our work, we focus on the development of a deep learning model that learns to predict stellar inclination and stellar period from simulated lightcurves. The model incorporates the most common non-learnable technic for period analysis (autocorrelation function) and a variation of Conformer- a special transformer architecture designed for time series analysis. By that, the model is able to catch both time dependent properties such as period and more global properties like Inclination. We applied our trained model on Kepler dataset and achieved the biggest current sample of period predictions (>80000). In addition, we were able to, at least partially, resolve the degeneracy between inclination and spot's location, and predict stellar inclination for general Kepler stars for the first time. Our model is simple and can be applied for other stellar properties predictions. It also has the potential to learn meaningful insights about the spot's mechanisms themselves.

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Session Classification: FlashTalks