Finding flares with recurrent deep neural networks

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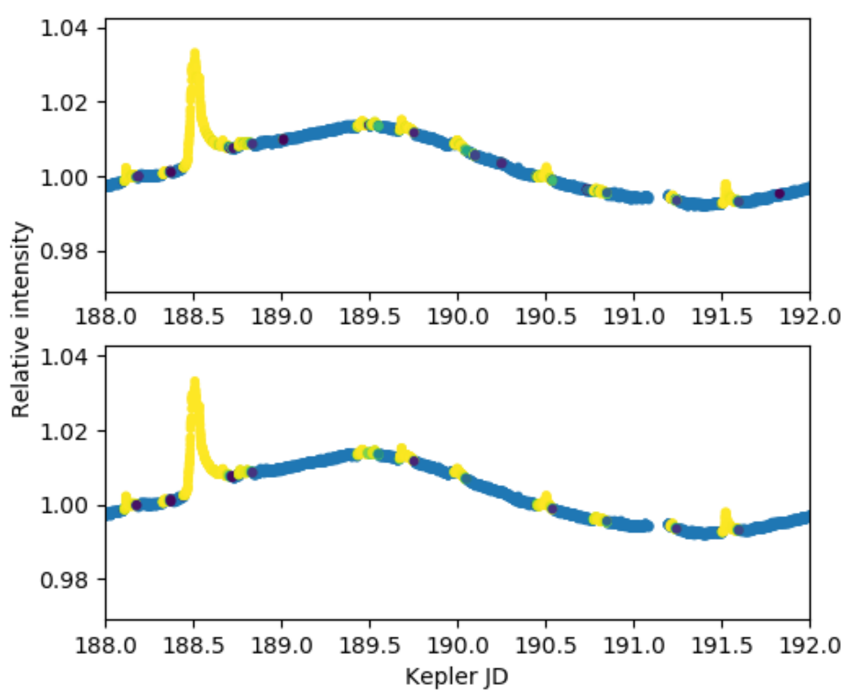
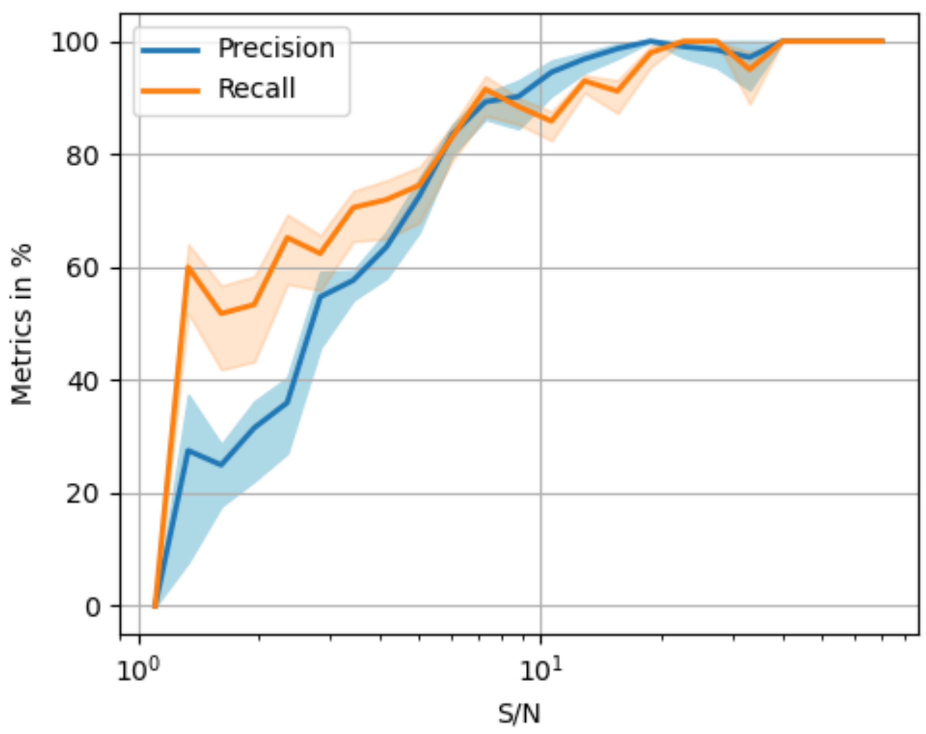
Stellar flares are an important aspect of magnetic activity—both for stellar evolution and circumstellar habitability viewpoints—but automatically and accurately finding them is still a challenge to researchers in the Big Data era of astronomy. We present an experiment to detect flares in space-borne photometric data using deep neural networks. Using a set of artificial data and real photometric data we trained a set of neural networks, and found that the best performing architectures were the recurrent neural networks (RNNs) using Long Short-Term Memory (LSTM) layers. The aim for the trained network is not just detect flares but also be able to distinguish typical false signals (e.g. maxima of RR Lyr stars) from real flares.



The output of the neural net. The plot on the top shows the raw output with points color coded with their probability if it is over 0.5. To correct for the few points within flares that are not marked (false negatives), and some single points that are incorrectly identified as flares (false positives) we apply smoothing to the output probabilities by a median filter (bottom plot panel). Since during the manual flare flagging of the training data we tried to include every small events, this increases the chance of false positive detections, but these can be easily filtered by a further validation step.



To train the tested neural networks we used both artificial light curves and real Kepler observations. The latter set consisted of real flaring stars & "astrophysical noise" (e.g. RR Lyræ) that typically confuse flare-searching algorithms. Flares were manually labeled for training. The plot shows the performance of the best neural network on an independent test dataset after training: flare events above ~5σ are recovered in 80% of the cases in the test data. Uncertainties in the metrics are estimated with KFold cross-validation (k=5)

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