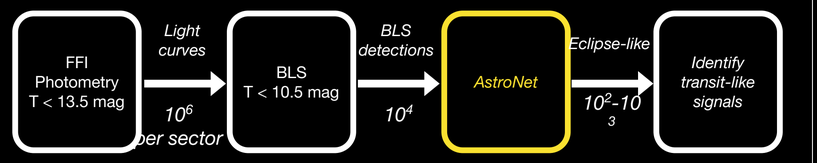
AstroNet for TESS

A high-quality dataset and trained model for classifying phase-folded light curves from TESS observations using deep learning

Dan Moldovan (Google), Anne Dattilo (UCSC), Chelsea Huang (MIT ⇨ USQ), Michelle Kunimoto (MIT), Avi Shporer (MIT), Evan Tey (MIT), Andrew Vanderburg (University of Wisconsin-Madison)

Quick Look Pipeline

Huang et al., 2021 a,b



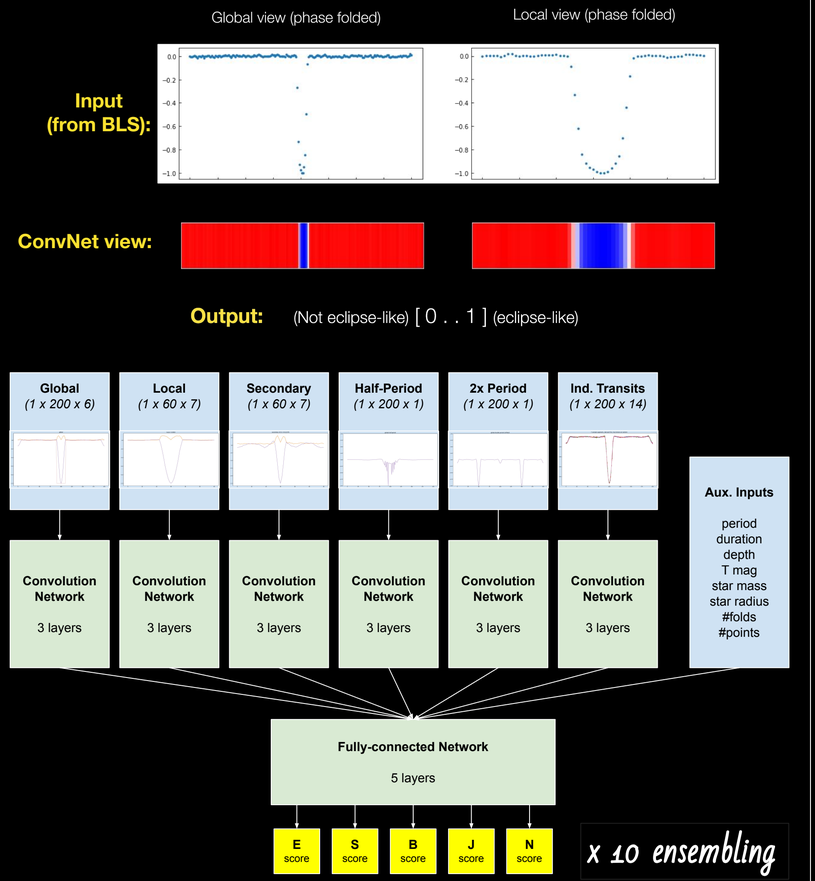
*QLP processes all T < 13.5 mag targets in a given sector, using all previously obtained data (mutli-sector).

The AstroNet Model

Deep convolutional neural network (ConvNet)

Yu et al. 2019, AJ, 158, 25; Shallue & Vanderburg 2018, AJ, 155, 94

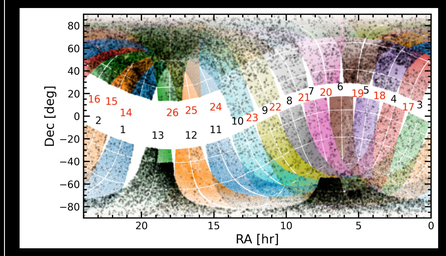
The AstroNet architecture is a convolutional neural network which processes phase-folded light curve features as 1-D images.

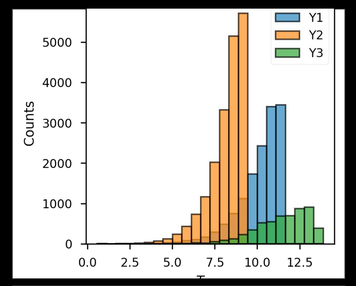


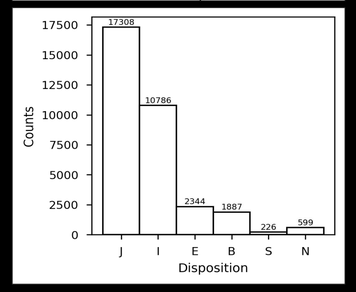
New triage dataset

We curated a new dataset to help train a new triage (quick exclusion of obvious negatives) network.

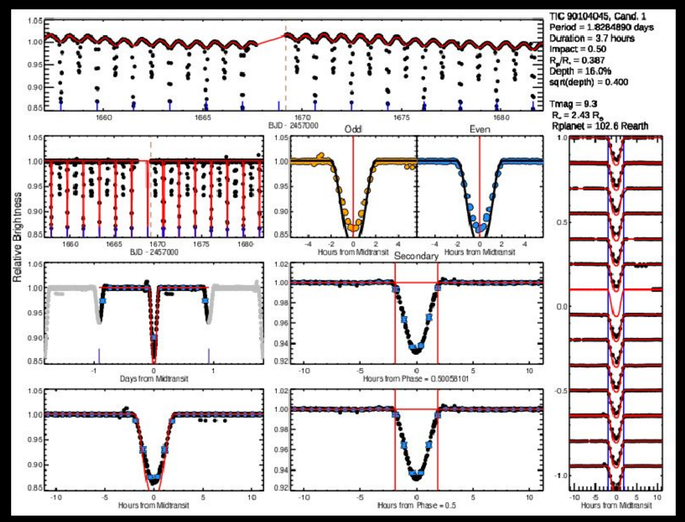
- ~20k examples
- N + S hemisphere
- excluding “in-star” orbits
- train/test split
  - training ~16k
  - validation ~2k
  - test ~2k







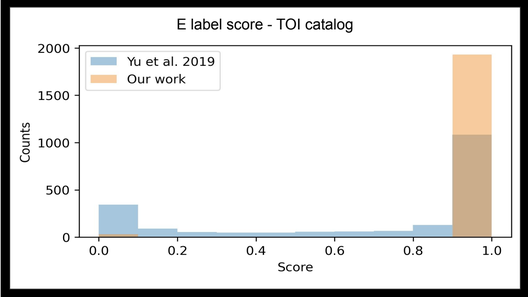
The dataset labels were created by human raters based on report images:

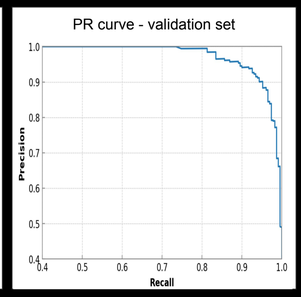


- human labels
  - **E** planet or binary star
  - **S** like E, single/wrong period
  - **B** contact binary
  - **J** junk
  - **N** undecided
- multiple independent raters
- mismatched ratings of E or S resolved as a group
- other mismatches assigned weighted labels (e.g. 50% J, 50% B)

Results for E vs. not-E label

- precision = TP / (TP + FP)
- recall = TP / (TP + FN)
- Validation set (low threshold = 0.03): ~ 60% precision @ 100% recall
- Extended mission S33 (low threshold = 0.03)
  - Cam 1: 73% precision, 97% recall
  - Cam 2: 66% precision, 98% recall
- Extended mission S33 (high threshold = 0.31)
  - Cam 1: 86% precision @ 93% recall (vs. 92% @ 85% for Yu19 model)
  - Cam 2: 85% precision @ 94% recall (vs. 81% @ 88% for Yu19 model)
- TOI catalog (low threshold = 0.03): 99.0% recall (19 false negatives)
- TOI catalog (high threshold = 0.31): 98.5% recall (30 false negatives)
- 6 confirmed false positives, removed from TOI





Discussion, next steps, future work

Deep learning models show great promise in automating the process of exoplanet detection. The architectures we currently use are still fairly basic and there is potential for superior results with more advanced models.

New astromodel applied to the Quick Look Pipeline since S34.

The current dataset does not distinguish between binary stars and planet systems. A new dataset that can distinguish between the two is in the works.

Among directions for future work:

- Data augmentation: better generalization
- Continuous learning: gradually increase training set by adding new vetting data
- End-to-end architecture: FFI -> prediction

See us at the ML splinter session on Wednesday!