Open Source Software Development for Transit Detection using Cloud Computing

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ABSTRACT

We describe the beginning stages of development for an open-source software suite designed to detect exoplanet transits using cloud computing. The goal of this project is to enable more collaboration of programmers from around the world in developing algorithms and codes related to detection of transit-like events, especially in Kepler data. We also hope that such software may be useful when TESS data are available. Our work extends the work of Berriman et al. (2010, 2012) in a few particular ways. We describe our use of the Amazon EC2 cloud to search for aperiodic transit-like events in Kepler light curves. Such events may be caused by circumbinary planets or very long-period transiting bodies, either planets or stars.

Accomplishments and Goals to Date

DONE:

- ✓ Assembled an initial group of collaborators (co-authors of this poster).
- ✓ Set up a github repository for code
  - ✓ https://github.com/ivanmladek/cloud-kepler
- ✓ Python Code tasks:
  - ✓ Retrieve and concatenate Kepler light curves from MAST.
  - ✓ Execute traditional Box-Least-Square BLS (Kovacs et al. 2002).
  - ✓ Execute our single-transit finder "Pulse BLS" (PBLS).

TO DO:

- ❑ Store Kepler data on these clouds for use by anyone.
  - ❑ Amazon EC2
  - ❑ Xsede.org cluster at San Diego
- ❑ Benchmark our versions of BLS and PBLS on those clouds.
  - ❑ Compare to Berriman's benchmarks for BLS on EC2.
- ❑ Insert light curve de-trending algorithm(s), or recruit participant(s) to do so.
- ❑ Execute PBLS.
  - ❑ Vet results. Debug. Iterate.
  - ❑ Estimate costs of running PBLS on all Kepler light curves.
- ❑ Deliver resulting table of transit-like events to MAST.
- ❑ Execute on simulated TESS data.
- ❑ Publish methodology and Kepler results.
- ❑ Search Kepler results for candidate circumbinary planets, triple stars, and long-period gas-giant planets.
- ❑ Consider additional applications.
  - ❑ Coordinate with human-eye methods, e.g. PlanetHunters.org (Schwamb et al. 2012)
  - ❑ Analysis of Full-Frame Images

Start hunting for planets

References

Berriman, G. B., Deelman, E., Juve, G., Regelson, M., & Plavchan, P. 2010, "The Application of Cloud Computing to Astronomy: A Study of Cost and Performance," arXiv:1010.4813

Berriman, G. B., Brinkworth, C., Gelino, D., et al. 2013, "A Tale Of 160 Scientists, Three Applications, a Workshop and a Cloud," Astronomical Society of the Pacific Conference Series, 475, 99

Kovacs, G., Zucker, S., & Mazeh, T. 2002, "[BLS] A box-fitting algorithm in the search for periodic transits," A&A, 391, 369

Schwamb, M. E., Orosz, J. A., Carter, J. A., et al. 2012, "Planet Hunters: A Status Report," AAS/Division for Planetary Sciences Meeting Abstracts, 44, #100.07

You are invited to join us!

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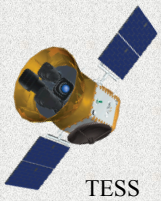
Near-term Scientific Goals

A near-term scientific goal is to produce a catalog of transit-like events using a version of BLS that we modified to enable it to find single transit-like events, which can be searched for pulse trains of aperiodic transits, such as those from circumbinary planets. This project is synergistic with the circumbinary planet research of Veselin Kostov (see his oral presentation at 9:40 AM Tuesday) and that of PlanetHunters.org.

Motivation, especially for TESS & JWST

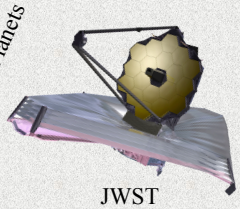
The Transiting Exoplanet Survey Satellite, TESS is sometimes called "the People's Telescope." TESS and JWST are scheduled for launch at approximately the same time (TESS, 2017; JWST, 2018). Because one of the primary uses of TESS data will be to identify targets for JWST follow up, and JWST has a 5- to 10-year lifetime, astronomers must quickly identify planet candidates from TESS data and vet them so that those which are interesting planets can be observed ASAP with JWST and other telescopes. TESS' data will have no proprietary period. These circumstances motivate our open-source software development, in order to be prepared when TESS data becomes available. Although the TESS team will develop its own pipeline, an open-source, cloud-computing architecture may provide an alternative method of identifying planet candidates with potential for more rapid, complementary, and perhaps better results than traditional methods. Democratization, only latent in non-proprietary data, is enhanced further by also making algorithms and computers available to all interested persons. The many discoveries still hidden within the public Kepler data are another motivation in the near term.


TESS

Light Curves

LOTS OF WORK!
NOT MUCH TIME!

The Best Planets


JWST

Second Kepler Science Conference, Nov 4-8, 2013, NASA Ames, CA USA