



A Web-based Plotting Tool for Education and Research of Star Clusters



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Abstract

Hertzsprung-Russell diagrams (HR diagram) are scatter plots of stellar luminosity over their intrinsic color, and patterns observed from HR diagrams illustrate important facts of stellar evolution, a key concept in astronomy. However, there lacks a way to teach stellar evolution and HR diagrams in a hands-on and interactive way in introductory astronomy courses. This research aims to create a web-based and accessible plotting tool that will allow students to plot their own observational and archival catalog data, filter out field stars with proper motion and distance, and fit an isochrone curve to it. The product, named Cluster Pro Plus, is currently under trial in multiple institutions as a part of the new curriculum: "Multi-wavelength Universe!" (MWU!) lead by Dr. Daniel Reichart and Dr. Daryl Janzen etc.

Background

Star clusters: Large groups of stars that are held together by gravity.

HR diagram: plots of stellar luminosity over intrinsic color, a powerful tool to illustrate and analyze stellar evolution.

Isochrone model: a theoretical model of the positions of stars that are all at a given distance, whose light is scattered by the same amount of interstellar dust, that are all the same age and have the same chemical composition, but which all formed with different masses. Appears as a line in HR diagram.

Proper motion: the relative motion of a star compared to very distant background.

Skynet Robotic Telescope Network: The 2nd largest robotic telescope network in the world with more than 20 telescopes in five countries in four continents. Students in MWU! use Skynet to collect star cluster data.

Methodology

The Cluster Pro Plus is a web app composed by a frontend single page application and a backend server. The frontend is a HTML-CSS-Typescript based website following a View-Model-Controller architecture, and the backend is a Python Flask application.

The development was split into three stages. The *Cluster* interface can load in user observations from Skynet, and plot isochrones. The isochrones models are produced by Dr. Michael Fitzgerald through simulation. The *Cluster Pro* interface adds a proper motion chart to let users filter out field stars that are not inside the cluster. The proper motion data are not part of user's observation, it's obtained by cross matching the sky coordinate with a local database using a fast algorithm named KD-tree. The *Cluster Pro Plus* interface fetches archival data based on users query from the GAIA, 2MASS, and APASS catalogs.

Results

Conclusion

The *Cluster Pro Plus* interface meets all the objective set at the start of the research. It's relatively responsive to user input when plotting stars and isochrone models. It also has a decent performance when cross matching GAIA and fetching, having most jobs complete within 1 minute. Access the tool at: <https://skynet.unc.edu/astr101/graph>

Next Steps

I wish to expand its ability to automatically compute the radius of a cluster and find the best isochrone fit. It'll also be migrated to a new frontend infrastructure based on the Angular framework.

Reference

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