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Double Trouble: Applying Deep Learning to EBS Systems

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Overview

Motivation: Obtaining prediction for the characteristics of stars in eclipsing binary systems is a slow process using current methods taking up to 3 months to generate results. A speedup would allow astronomers to research our galaxy more effectively.

Goal: Rapidly and accurately predict characteristics of eclipsing binary star systems.

Approach: Use deep learning with various approximation methods.

Background

Astronomy:

- Eclipsing binary star systems: two stars revolve around each other
- Each star has characteristics such as a radius, temperature, mass, etc.
- The stars emit observable, periodically varying light curves

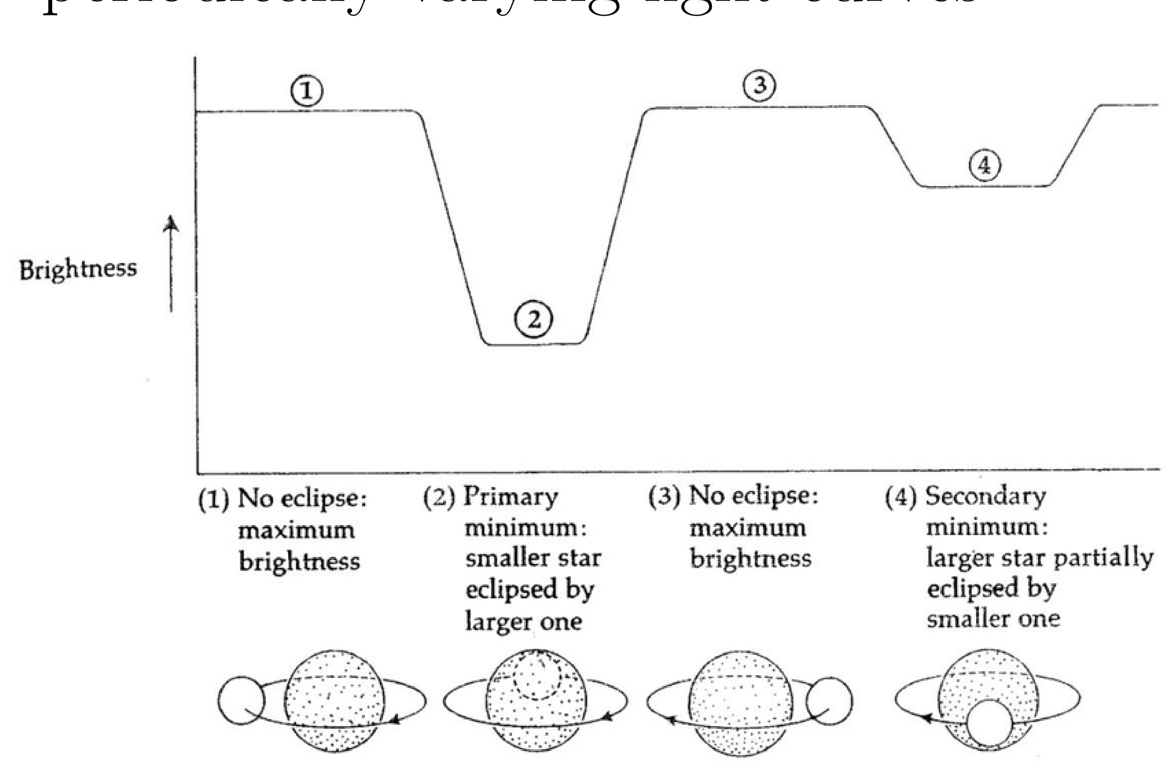


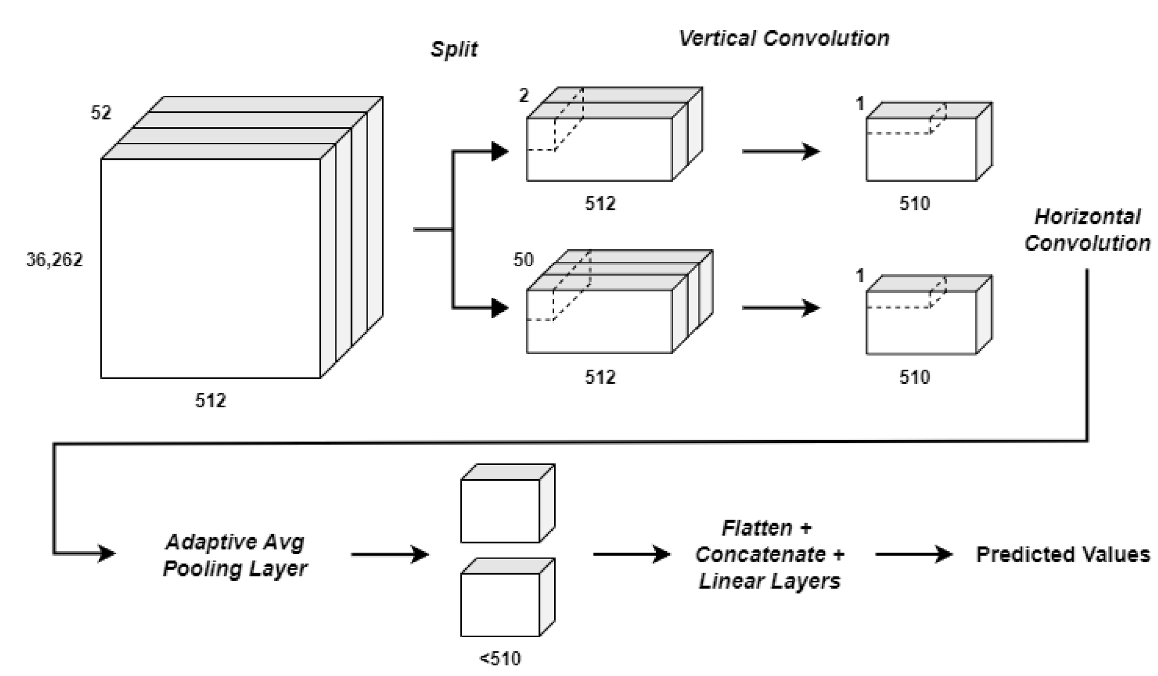
Figure: Binary Star System and Light Curves

www.researchgate.net/figure/Figure-8-Light-curve-of-eclipsing-Binary-Stars_fig6_320346142

Machine Learning:

- The deep learning technique we utilize is a custom neural network architecture for regression
- Our model takes in the light curve and radial velocity data and outputs a numerical prediction for each characteristic of the stars

Model



The input tensor is split into radial velocity and light curve channels. These are vertically then horizontally convolved over, put through an average pooling layer, and finally flattened and concatenated to be passed through linear layers to produce predicted values.

Dataset

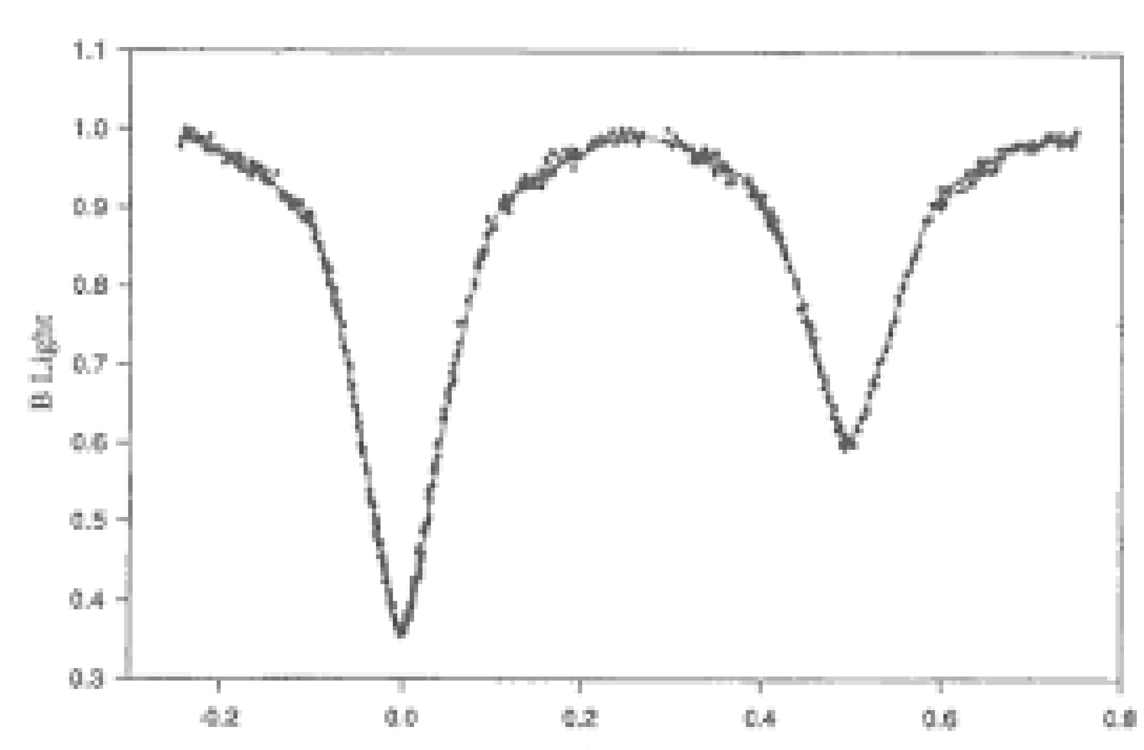


Figure: EBS Wave

Input Size:

- Number of data points: 35,262 x 512
- Number of features: 52

18 Targets, including:

- Mass of the individual stars
- Phase of the system
- Effective temperature of the stars in the system

Inputs:

- Wavelength separated light curves (512 intervals each)
- Radial velocity curves
- Period as metadata

Results & Analysis

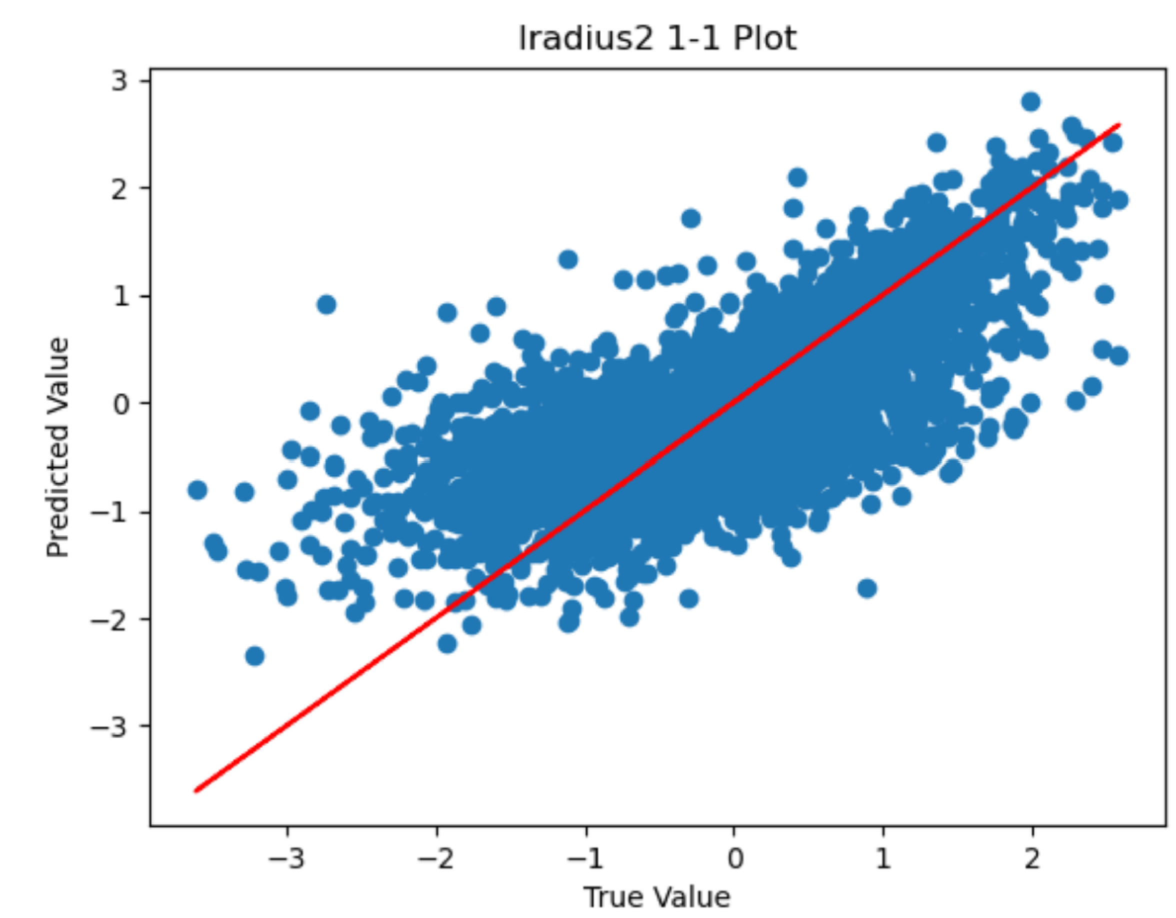


Figure: 1-to-1 Plot of Single Star Radius values

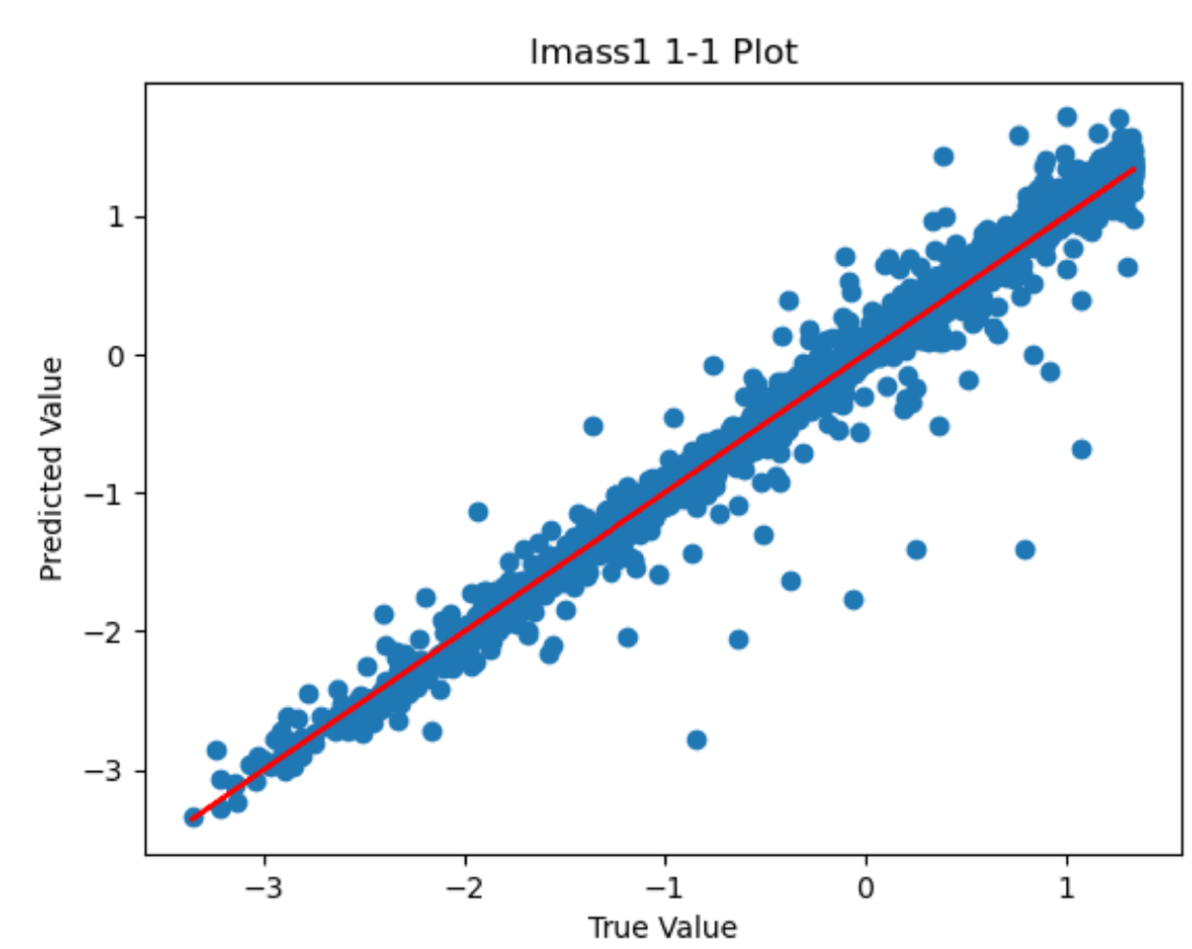


Figure: 1-to-1 Plot of Single Star Mass Values

Analysis:

- Performing well on parameters directly related to the period and those easy to compute
- Struggling on more complex parameters such as the effective temperature of the stars
- Model performance on predicting all 18 parameters has .35 RMSE

Conclusions & Future Work

- Convolutional neural network and metadata usage improve our accuracy
- Bayesian neural network for confidence of prediction scores
- Training model to predict from random subsets of the input data