A Saddlepoint approximation test for period detection: Application to lightcurves

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Abstract

Estimating accurately the period of time series is a commonly occurring problem. When the sampling of the data occurs at irregular time points, an extra level of complexity is added. Data like that occur in many fields such as biology, economics or as we will examine here, astronomical light curves. These are complex time series at irregularly spaced time observations. For a particular star, there is also additional information related to the measurement accuracy for each observation data point. In order to determine their cyclic behavior (since it is of high interest to the astronomy community), we examine a type of empirical periodogram described as follows:
1.Select a sequence of trial periods,
2.Fit each time a preferable model with a periodic assumption,
3.Evaluate some goodness of fit measure, which defines the periodogram entries for each period.

The values generated in step three above define some measure of validity for each period. As a rule of thumb, extreme values in such periodograms point to the valid periods. However, some understanding of the distribution of the periodogram is needed in order to determine what is extreme and what is not. Here we will focus on non parametric periodograms, in particular a weighted Gaussian process regression periodogram. Most importantly we will introduce a test for quadratic forms in order to detect valid periods using saddlepoint approximations, as a faster and more accurate alternative to simulation-based methods. Moreover, we will extend this approach to correlated noise backgrounds and finally we will present our results for some real light curves.

Keywords

Periodogram, Normal Quadratic Forms, Hypothesis Testing, Gaussian Process regression.

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