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Stellar Variability Detection in the Era of Virtual Observatories

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Abstract. Large compilations of photometry data are expected in the coming virtual observatory era. Previously known variability indices and period determination methods are not robust enough to allow fully automatic examination of time series data. We have developed a new approach to detect stellar variability in heterogeneous time-series data with a distributed computing environment. The test of OGLE and SkyDOT data shows encouraging results when the observed data are compared with a set of simulated ones, using properties of periodic variability in the phase domain and combining various well-known statistical indices.

1. Variability Test Method

We compare the variability detection efficiency in the time domain with different indices using 1775 time- series data of the OGLE II (Udalski et al. 1997) LMC SC 11 field. Thirty artificial data sets were generated for each observed time series with the same mean and standard deviation by assuming a normal distribution of measurement errors. Comparison between real data and artificial data was conducted for consecutiveness (Con, Wozniak 2000), variogram (Eyer et al. 2002), maximum of analysis of variance(AoVMm, Schwarzenberg-Czerny 1996), and Stetson's J/K indices (Stetson 1996). If a given time series showed an index that exceeded a statistical cut estimated from indices of 30 artificial data, they were classified as variable candidates. In the time domain, 90% of true variables are recovered and Con, J, and the combination of K and AoVM find 49.9%, 34.2%, and 5.9% of these variables, respectively. (See Fig. 1)

Data classified as non-variables in the time domain were passed through a similar test in the phase domain, after the observation data and 30 artificial data were folded with the most possible period (Shin & Byun 2004). The indices used were Con, Stetson's J/K/S, the combination of J, K, S (Comb), and AoVM. Another 7.8% of the variables were detected, because these indices in have different correlation patterns in the time and phase domains as shown in the right plots of Fig. 1.

About 98% of true variables were recovered while producing zero false detection. The missing 2% is suspected to be related to difficulty in period estimates.

2. Application to SkyDOT Database

Our experiment with two fields from SkyDOT, NSVS 072b and NSVS077b, recovered all previously known variable stars (Wozniak et al. 2004). In the NSVS 072b field, about 64% stars were classified as possible variables in the time domain search, while 24% of NSVS077b stars were chosen. However, no variable candidates were detected in the phase domain, because an inaccurate period plays against successful detection.

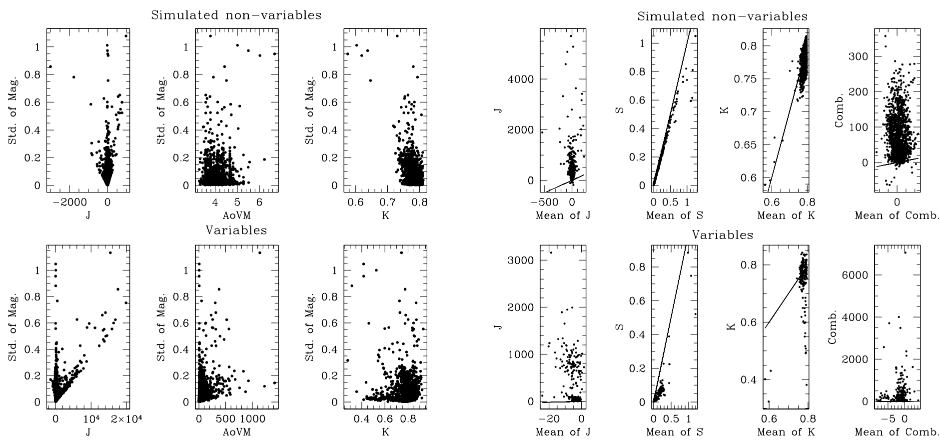

Figure 1. (left) Indices in the time domain show different correlation patterns for simulated data and variable stars. (right) In the phase domain, a distribution of various indices for non-variables generally follows the straight lines. But the dispersion of the distribution is different for each index.

3. Conclusion

We have introduced a robust approach to identify variable stars from large time-series databases and demonstrated its efficiency. While further experiments are needed, we anticipate the following: 1) this approach is well suited for data consisting of different statistical properties or noise characters; 2) distributed processing can be fully utilized because the analysis does not depend on the properties of other data or the statistical properties of a data set as a whole; and 3) simultaneous usage of different indices in both time and phase domains will be useful in finding low-amplitude variability.

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