EPSC Abstracts
Vol. 13, EPSC-DPS2019-1241-1, 2019
EPSC-DPS Joint Meeting 2019
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EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Classification of TNOs detected by stellar occultation using a SVM

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Abstract

We present a new pipeline based on the algorithm of Support Vector Machine (SVM) for the classification of small objects detected by serendipitous stellar occultation. The pipeline is designed to analyze light curves and determine both: the existence of an occultation event and the size/distance of the occulting object based on its diffraction signature. We find that the efficiency of the event detection is much higher than the efficiency of classification and that this last procedure highly depends on the signal to noise ratio (SNR) of the light curve.

1. Introduction

In astronomy is well known that SVMs are useful tools for classifying objects and physical parameters automatically [1, 2, 3]. Even when most input data for SVMs are images and/or spectra provided from telescopes, in this work we are using light curves, however, the same logic can be applied for classifying. The input light curves for this pipeline were obtained from the event simulator for the Transneptunian Automated occultation Survey (TAOS II) [4]. The algorithm, after trained, is aimed to: look for a diffraction signature among a great amount of light curves, confirm an event and deliver the size and distance of the object that produced the occultation. Since the algorithm will be searching for diffraction signatures, it can be used to work with any other survey which looks for occultations.

2. Methodology

There are two principal components to be determined before designing a SVM: the input data and the features of the problem. The input data are simulated diffraction profiles which depend on several parameters [4]: object size D_{eff}, object distance z, wavelength λ, spectral type of the star S, impact parameter b, time offset t_{off}, inclination from the opposition angle θ, the apparent magnitude of the star V and the readout cadence R. Then a single light curve is function of all these parameters $\gamma(D_{eff}, z, \lambda, S, b, t_{off}, \theta, V, R)$. From the combination of all these parameters we have simulated 4,860 classes. Now to generate the light curve is necessary to add noise to each class:

$$\Gamma_i = \gamma_i(.) \oplus \eta(SNR) \quad (1)$$

The noise η depends on the SNR that results from the combination of the star brightness and the observing system.

Now the features were carefully chosen taking into account the general shape of an occultation signal. Each feature is a mathematical operation f over Γ.

$$\tau_k = f_k(\Gamma_1, \Gamma_2, \Gamma_3), \quad (2)$$

where Γ_1, Γ_2, Γ_3 are light curves from three different telescopes. We divided all features in four groups: three statistic operations, four changes in energy or derivatives, nine Gaussian spaces and twelve points of interest [5], in total 18 features.

3. Figures

In fig. 1 light curve of example with $SNR = 21$ is shown. In red the diffraction profile is highlighted to show the original signal before adding noise.

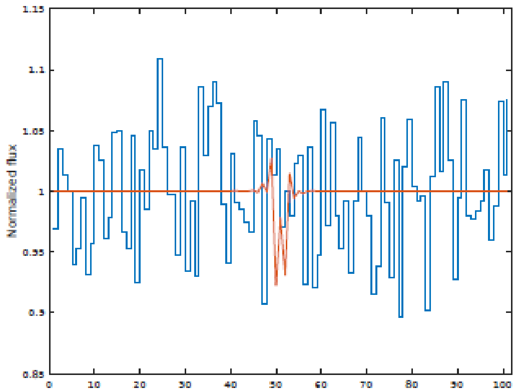

Figure 1: An input light curve *V=14*, *S=A3V*, D_{eff}*=0.5 km*, *z=50 AU*, *b=0*, t_{off}*=0.5*.

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Figure 2. Results for detection and classification of size and distance for light curves of *V=14* and *S=A3V*.

In fig. 2 we show the results of the detection and classification of 54,000 light curves of different classes with *V=14* and *S=A3V*. The SVM successfully detected and classified in size and distance the 90.1 % of all the light curves.

4. Summary and Conclusions

We have developed an algorithm based on a SVM for detecting occultation events.

The algorithm is able to classify simulated light curves with diffraction profiles embed in noise, according to size and distance of the occulting object.

Even when the algorithm was designed for data coming from the TAOS II project, with minor modifications is possible to use it in any survey looking for stellar occultations.

Acknowledgements

This work was supported in part by the Universidad Nacional Autónoma de México and Academia Sinica. We acknowledge support from Cátedras-CONACYT project 219, from CONACYT through CB project 283800 and from DGAPA-UNAM project IN107316.

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