Contrib. Astron. Obs. Skalnaté Pleso **55/3**, 374 – 376, (2025)
https://doi.org/10.31577/caosp.2025.55.3.374

# Classification of light curves of eclipsing binaries using deep-learning models

**Š. Parimucha**[1], **Y. Markus**[1,2], **P. Gajdoš**[1,3] **and V. Kudak**[4]

[1] *Institute of Physics, Faculty of Science, Pavol Jozef Šafárik University, Košice, Slovakia, stefan.parimucha@upjs.sk*

[2] *International Center of Astronomical, Medical, and Ecological Research, NASU, Kyiv, Ukraine*

[3] *Astronomical Institute of the Czech Academy of Sciences 251 65 Ondřejov, The Czech Republic*

[4] *Laboratory of Space Researches, Uzhhorod National University, Uzhhorod, Ukraine*

Received: November 14, 2024; Accepted: January 20, 2025

**Abstract.** This paper introduces a hierarchical deep-learning classification model for eclipsing binaries, where the period is also considered. Our classifier provides a tool for categorizing their light curves into four groups: overcontact with/without spots and detached with/without spots. We applied our model to light curves of OGLE eclipsing binaries and showed that it is reliably classified, although the precision of classification depends on the light curve quality.

**Key words:** stars: binaries: eclipsing – deep-learning

## 1. Introduction

Eclipsing binaries (EBs) are systems in which the mutual eclipses of components cause typical light curves (LCs). From LCs, we can determine many parameters of the system and stars: their sizes and shapes, potentials, photometric mass ratio, relative temperatures, inclination of the orbital plane, and presence of irregularities caused by spot(s) and/or pulsations. To determine these parameters, it is necessary to know if the components in the binary are inside their Roche lobes (detached system) or if they have a common envelope (overcontact systems). To process large amounts of EBs from ongoing and future surveys, human effort is practically impossible. Therefore, it is necessary to develop other procedures based on deep-learning methods. The first step is the classification of EBs based on their observable properties. For most of them, it is a light curve obtained in one passband and the orbital period.

Parimucha et al. (2024) suggested a scheme based on a deep-learning model that classifies light curves directly into four groups based on their shapes. In this model, they did not consider a period as an input parameter. This has led

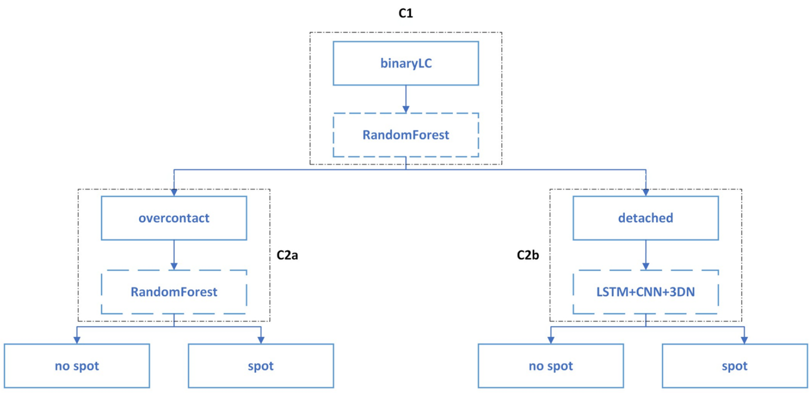


**Figure 1.** The hierarchical model of the classification scheme and the best models.

to a relatively large amount of misclassification, mainly for binaries with longer orbital periods, which were wrongly classified as overcontact.

This study extended the model for orbital periods to improve the classification precision. This approach allows us to classify all EBs already found in large surveys, such as GAIA, KEPLER, or TESS. It will also be found in prepared surveys like the Vera Rubin Observatory (LSST).

## 2. Deep-learning model, training and evaluation datasets

The training dataset was created using the ELISa code (Čokina et al., 2021). LCs were simulated for overcontact and detached binary systems with a wide range of realistic stellar, system (including orbital periods), and spot parameters. Each LC has 100 equidistant points and is phase-folded and normalized to the maximum flux. We created a dataset of more than 2.5 million LCs.

For evaluation of our model, the OGLE Eclipsing and Binary Stars Catalog (Soszyński et al., 2016; Pawlak et al., 2016) was used, including EBs from the galactic bulge, LMC, and SMC, classified as contact (C) and non-contact (NC) systems. The LCs in the I passband were folded by catalogue periods, binned into 100 points, and normalized to the maximum flux for consistency with the training dataset.

Our classification scheme enables a hierarchical approach using different models for each group to improve performance and training speed. We selected 100,000 light curves (LCs) per group from the training set and augmented them using Gaussian noise. 20% of the data was reserved for validation.

The classification scheme and best models are shown in Fig 1. The precision of each model on the validation dataset is 97.8%, 95.1%, and 92.7% for C1, C2a, and C2b, respectively.

## 3. Application to OGLE eclipsing binaries

Our model was applied to the OGLE Eclipsing Binaries Catalog. The key results of our analysis are summarized as follows.

– the model classified nearly all OGLE contact binaries (C) as overcontact, with only a few exceptions,
– many OGLE non-contact (NC) binaries were classified as overcontact, suggesting possible OGLE data misclassification,
– spot detection in LMC and SMC data was challenging and less reliable, due to observational limitations, especially for faint stars with high scatter. More spotted binaries were classified in the bulge, which was likely also underestimated due to light curve (LC) quality.

## 4. Conclusion

The hierarchical classification approach described in this study demonstrates strong performance when applied to the OGLE dataset, suggesting its suitability for comprehensive analysis of eclipsing binaries in large-scale astronomical surveys. The robustness of the model for differentiating between overcontact and detached systems, even with spot detection limitations, points to its potential for future use in projects such as the Vera Rubin Observatory (LSST).

**Acknowledgements.** This research was supported by the Slovak Research and Development Agency under Contract No. APVV-20-0148. Y.M. was funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under project No. 09I03-03-V01-00011. The research of P.G. was supported by the internal grant No. VVGS-2023-2784 of the P.J. Šafárik University in Košice and funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V05-00008. V.K. was supported by Ukrainian National Grant 0122U000937.

## References

Parimucha, Š., Gajdoš, P., Markus, Y., & Kudak, V., Deep-learning classification of eclipsing binaries. 2024, *Contributions of the Astronomical Observatory Skalnate Pleso*, **54**, 167, DOI:10.31577/caosp.2024.54.2.167

Pawlak, M., Soszyński, I., Udalski, A., et al., The OGLE Collection of Variable Stars. Eclipsing Binaries in the Magellanic System. 2016, *Acta Astronomica*, **66**, 421, DOI:10.48550/arXiv.1612.06394

Soszyński, I., Pawlak, M., Pietrukowicz, P., et al., The OGLE Collection of Variable Stars. Over 450 000 Eclipsing and Ellipsoidal Binary Systems Toward the Galactic Bulge. 2016, *Acta Astronomica*, **66**, 405, DOI:10.48550/arXiv.1701.03105

Čokina, M., Fedurco, M., & Parimucha, Š., ELISa: A new tool for fast modelling of eclipsing binaries. 2021, *Astronomy and Astrophysics*, **652**, A156, DOI:10.1051/0004-6361/202039171