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Machine Learning explorations in GRB Studies: from classification to extended emission identification

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Gamma-ray bursts (GRBs) have traditionally been classified based on their duration. Nevertheless, extended emission (EE) GRBs, characterised by a duration larger than two seconds and properties similar to short GRBs, challenges the conventional classification methods. By using a non-supervised machine-learning technique (t-distributed stochastic neighbor embedding, t-SNE),we performed a better phhotometric classification and the identification of extended emission in Swift/BAT GRBs. Furthermore, we introduce an innovative tool, `ClassiPyGRB`, designed for astronomers whose research centers on GRBs from Swift/BAT telescope.

Gamma-ray bursts (GRBs) have been classified mainly considering their duration (Kouveliotou et al., 1993). Short GRBs (SGRBs) typically last less than than two seconds, exhibit harder spectral properties, and are associated with the merging of compact objects, such as neutron stars or a neutron star and a black hole (i.e., Berger, 2014). On the other hand, long GRBs (LGRBs) have a duration larger than two seconds, a softer emission, and are associated with the collapse of massive stars (i.e., Bromberg et al., 2012).

EEGRBs challenge this classification scheme by having a total duration larger than 2 seconds but sharing characteristics of both SGRBs and LGRBs (i.e., Gehrels et al., 2006). Finally, duration classification also has instrumental selection effects, as demonstrated by Qin et al. (2013). This evidence remarks the need for a more comprehensive understanding of GRBs and motivates further exploration into alternative classification criteria.

Jespersen et al. (2020) proposed a new classification scheme based on similarity analysis via t-SNE, a popular machine learning (ML) algorithm. Although its classification discerns two subgroups of GRBs, they do not consider the impact of noise in their classification, and their dataset is currently outdated.

In García-Cifuentes et al. (2023), we use a dataset consisting of BAT GRBs observed until July 2022 by the Swift/Burst Alert Telescope instrument in all its energy bands. We reduced noise on the light curves using the Bayesian approach `FABADA` (Sánchez-Alarcón & Ascasibar, 2023). Subsequently, we preprocessed the noise-reduced light curves using the same procedure as Jespersen et al. (2020), and we applied t-SNE implemented on `scikit-learn` in *Python3*.

One of the most relevant results obtained in our research is that it is possible to discern two subgroups of GRBs in the t-SNE maps, and their properties are similar to those related to SGRBs and LGRBs. Moreover, our research highlights the relevance of handling noise in ML-based classifications, and we show that the dependence on duration remains invariant despite reducing noise.

On the other hand, it is possible to discern small clusters of EEGRBs in the reduced-noise classification. The most significant outcome of our research is that, by examining the nearest neighbors of previously identified EEGRBs, we can effectively classify new instances of EEGRBs. This approach not only streamlines the analytical effort but also introduces a novel method for classifying such events.

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