Classipy GRBs: Identification of Extended Emission Gama–Ray Bursts Candidates Using Machine Learning

Authors:

M. Sc. Keneth Garcia Cifuentes Dr. Rosa L. Becerra (Presenter) Dr. Fabio De Colle

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Introduction **CURRENT CLASSIFICATION**

The identification of subclasses in the GRBs is evidenced by plotting the histogram of its duration T90 and its cut-off at 2 seconds

T90 interval is defined by the time at which 5% and 95% of the total counts have been detected.



- Isolated progenitors?
- Instrumental selection effects

So...

...the classification is not perfect!

Objectives **Classification of GRBs**

USING A MACHINE LEARNING APPROACH WE COULD:

- Find correlations based on GRBs' light curves or their features.
- Associate them with their progenitors and subjacent physical processes.
- Provide a simple way to characterize any event concerning the total sample rapidly.



Research Timeline

 Uses datasets from Swift/BAT, BATSE, and Fermi GBM • Discern two groups of GRBs within the first burst second

• Confidence analysis, EE GRBs cannot be robustly classified

• Found KN-associated GRBs are located in separate clusters

Data

THE NEIL GEHRELS SWIFT OBSERVATORY

Dataset

1527 light curves of GRBs from Swift/BAT Available in: *swift.gsfc.nasa.gov/results/batgrbcat/*

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Example: GRB060614 light curve in 64ms

Data Pre-processing

GRBs vary significantly in duration, it is essential to standardize the data set of each event in such a way that preserves intrinsic properties but removing differences without a physical origin **1**.

2. Reduce Noise

[1] Jespersen et al. (2020) ApJL, 896, L20.

1. Limit out of duration intervals

3. Normalize by total fluence of each event

4. Standardize the size of events: Zero-pad

5. Perform Discrete Fourier Transform

ABOUT

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t-SNE is a popular non-linear dimensionality reduction technique used for visualizing high dimensional data sets.

ADVANTAGES

t-SNE has an impressive ability to create compelling twodimensional maps from data with hundreds or even thousands of dimensions.

t-SNE in a nutshell

DISADVANTAGES

t-SNE doesn't always produce similar output on successive runs, and there are additional hyperparameters related to the optimization process.

Classification Results

Classification Properties

Key Points

- Similar to duration-based classification
- It is based on light curve properties, instead of one single parameter

Garcia-Cifuentes, K. et al. (2023)

Extended **Emission GRBs**

Key Points

Hybrid events, as EEGRBs, appears to be located on the edge of the diagrams.

Steinhardt et al.(2023) state:

"Tiny groups or individual objects" with unique properties can be attached to the most similar group"

through t-SNE maps

Garcia-Cifuentes, K. et al. (2023)

Ultra Long GRBs

A nearly complete sample of Swift-detected GRBs with measured redshifts. Categorizing the sample to Bronze, Silver, and Gold by fitting a Gaussian function to the log-normal of T90 duration distribution

- Magnetar engine
- BH engine

Figure 4. t-SNE distribution map for *Swift*-BAT GRBs 64 ms binned light curves are grouped into two main classes. Green and orange colored circles represent our Silver and Bronze sub-samples, respectively. Red and magenta squares represent the Gold and Diamond sub-samples. GRB 221009A is shown with a red star.

Ror et al. ApJ, 2023

EEGRBs Candidates

Nearest neighbors to previous EE:

- GRB 200716C
- GRB 180618A
- GRB 080123

Our method is correct

Garcia-Cifuentes, K. et al. (2023)

ClassiPyGRB

Open-source Python3 package to download, process, visualize and classify Gamma-Ray-Bursts (GRBs) from the Swift/BAT Telescope

ClassiPyGRB Repository

https://github.com/KenethGarcia/ClassiPyGRB

Contact info

Thank You!

Machine Learning Explorations in GRB Studies

rosa.becerra@roma2.infn.it keneth.garcia@correo.nucleares.unam.mx fabio@nucleares.unam.mx

ClassiPyGRB Repository

https://github.com/KenethGarcia/ClassiPyGRB/

Classification Framework Convergence

There is a clear correlation between each GRB duration and its position on the map Iteration: 0

Credits: ClassiPyGRB

Hyperparameter Optimization Perplexity

"It is related to the number of nearest" neighbors that is used in other manifold learning algorithms"

Key Points

- Duration structure remains independent
- At low perplexities, the cluster separation increases

Credits: ClassiPyGRB

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Hyperparameter Optimization Learning Rate

The learning rate controls the step size of the gradient updates.

Key Points

- Duration structure remains independent
- At low perplexities, adjusting learning rate plays a significant role in separating clusters

Credits: ClassiPyGRB

