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Deep Learning Models for Detecting and Localizing Gamma-Ray Bursts in Sky Maps and Time Series: Applications to AGILE and COSI Missions

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AGILE is a high-energy astrophysics space mission launched in 2007 which terminated the operations in 2024. Its payload is comprised of the Gamma-Ray Imaging Detector (GRID), the SuperAGILE X-ray detector, the Mini-Calorimeter (MCAL), and an AntiCoincidence System (ACS).

Over the past few years, the AGILE Team has developed deep learning (DL) models to analyze sky maps and time series acquired by AGILE detectors.

The first method developed is designed to detect Gamma-Ray Bursts (GRBs) in the GRID sky maps above 100 MeV. The model detected 21 GRBs from an input list. We developed an additional DL model to localize GRBs in sky maps.

Then, we implemented a method to perform anomaly detection on time series data generated by the AGILE ACS to identify GRBs. The DL model detected 72 GRBs, 15 of which for the first time in the AGILE data.

We implemented a new deep neural network to predict the expected background count rates of the ACS based on the orbital and attitude parameters of the AGILE satellite. The difference between predicted and acquired count rates in the ACS data is used to detect GRBs. Using this method, we detected 39 GRBs, between them four GRBs are new detections in the AGILE data.

We determine the p-value distribution for all DL models to evaluate the statistical significance of the detected GRBs.

Moreover, we are developing Quantum Deep Learning (QDL) models to compare them with the classical ones. The goal is to figure out how to exploit the quantum computer features.

Finally, we are developing DL models for the COSI space mission starting from the know-how acquired with AGILE. The first model aims to localize the GRBs using the count rates of the anticoincidence BGO panels and another model aims to predict the BGO background rate expected as a function of the orbital and attitude parameters to detect GRBs when the acquired rate exceeds the predicted one.

Primary author: Dr PARMIGGIANI, Nicolò (INAF/OAS Bologna)

Co-authors: RIZZO, Alessandro (INAF/OA Catania); Dr URSI, Alessandro (ASI); CIABATTONI, Alex (INAF/OAS Bologna); DI PIANO, Ambra (INAF/OAS Bologna); Dr BULGARELLI, Andrea (INAF/OAS Bologna); Dr ZOGLAUER, Andreas (Space Sciences Laboratory at the University of California, Berkeley); Dr MACALUSO, Antonio (German Research Center for Artificial Intelligence); Dr PITTORI, Carlotta (ASI/SSDC); Dr CAVAZZUTI, Elisabetta (ASI); PANEBIANCO, Gabriele (INAF/OAS Bologna); Dr TOMSICK, John (Space Sciences Laboratory at the University of California, Berkeley); CASTALDINI, Luca (INAF/OAS Bologna); Prof. TAVANI, Marco (INAF/IAPS Roma); FALCO, Riccardo (INAF/OAS Bologna); Dr FIORETTI, Valentina (INAF/OAS Bologna)

Presenter: Dr PARMIGGIANI, Nicolò (INAF/OAS Bologna)

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