Radiation Guard:

Detecting anomalies in gamma time series

Ricardo CHIQUETTO, Maxsuel FERNANDES, Samara NDIAYE, Ana C. REGHINI, Lucas TRAMONTE

Professor Elisabeth Lahalle

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Filière Métiers de la Recherche

Gamma radiation

Monitoring gamma photons is used to analyze radiation levels and ensure they stay within safe limits. Detecting anomalies in this time series can indicate for example the occurrence of **nuclear accidents**. In astronomy, this data can also be used in **space monitoring**.

The goal of this study is to apply an unsupervised learning method to detect signal anomalies.

Figure 1: Mira Autonomus Monitoring Station to weather and gama radiation.

Anomaly detection

Dataset: the radiation acquired for 28 days in February, April, June, and October

Outlier removal: probable sensor error

Data training preparation: removing anomalies with moving standard deviation criterion [1]

Neural network model: choice of long short-term memory (LSTM) based on previous work with time series [2, 3]

Training: with nonanomolous data from the first three months

Threshold determination: stablishing static or dynamic thresholds to detect anomalies [2, 3]

Test: Apply the trained model on the October data in order to detect its anomalies

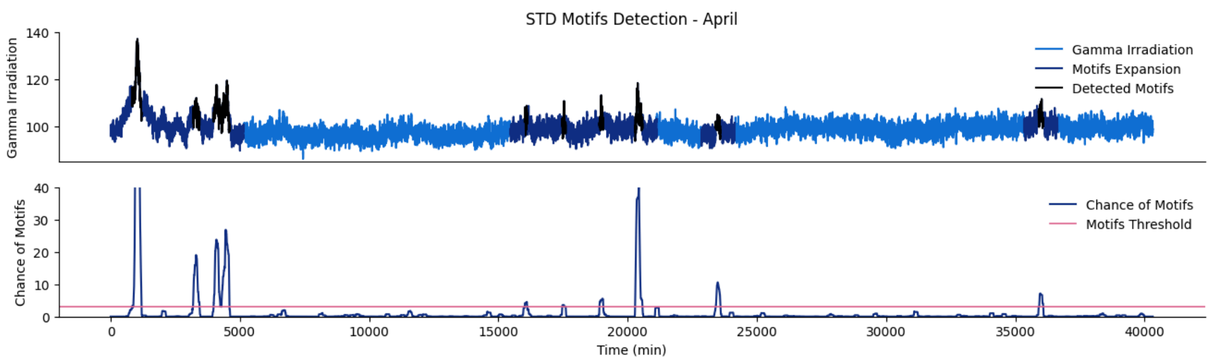

Figure 2: Anomalies detected in April data with STD method

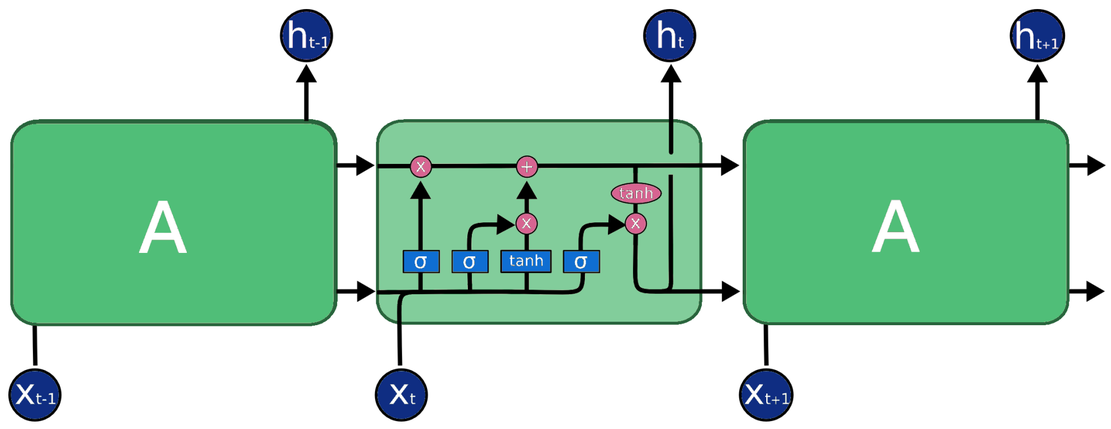

Figure 2: LSTM schema

LSTM application

The LSTM is trained on nonanomalous data in order to accurately predict the next value given a sequence.

Gaussian error for thresholding: the error obtained for the validation set is assumed to follow a normal distribution and a threshold is set to have the best trade-off between precision and recall.

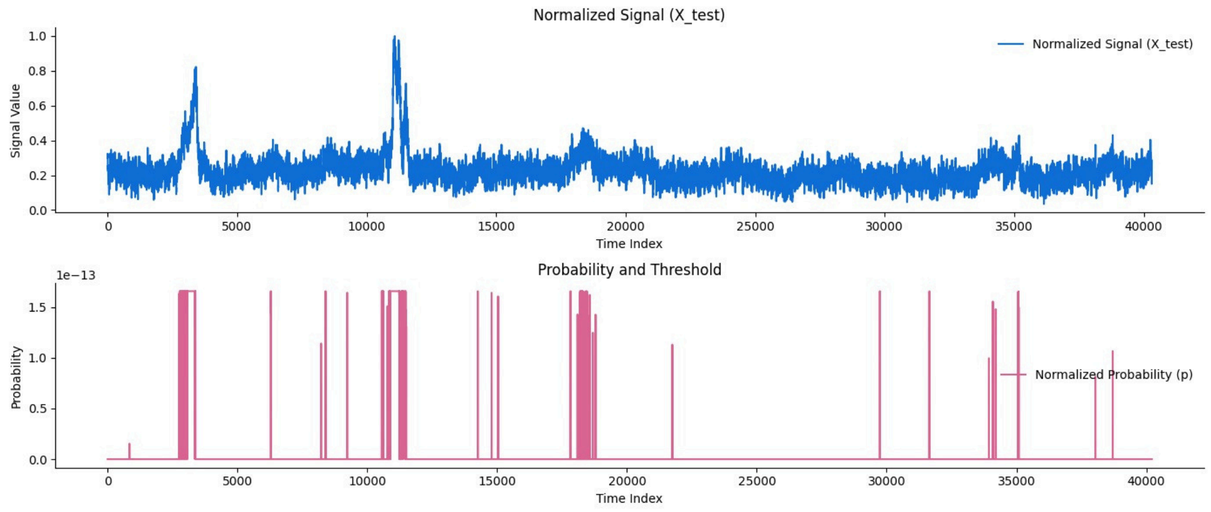

Figure 3: October result of LSTM model using gaussian thresholding

Dynamic thresholding: a window of fixed size slide over the sequence of errors and the best threshold for the window is set. No assumption about the distribution of the errors is made.

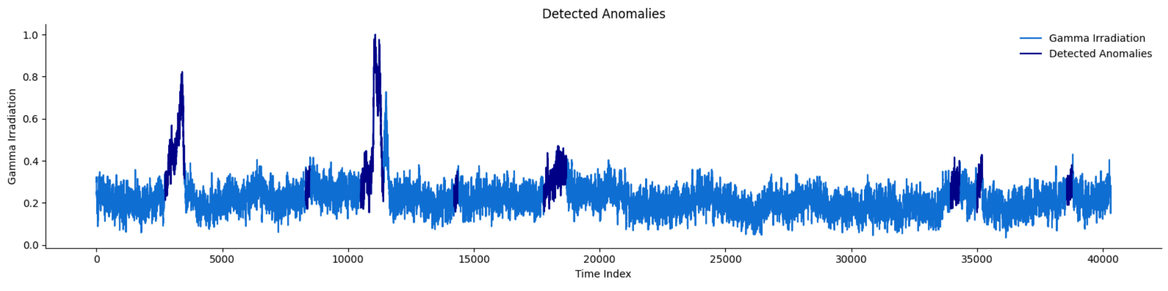

Figure 4: October result of LSTM model using dynamic thresholding

The LSTM has been able to detect most of the anomalous motifs (indicated by the high probability in Fig. 3), but with some false positives.

And so...

Both tested methods (moving STD and LSTM) had equivalent results, detecting most of the motifs and returning some false alarms too. The second one has more possibilities to be enhanced and the results were just limited by development time.

[1] Poirier et al. (2022). Unknown-length motif discovery methods in environmental monitoring time series.
[2] Hundman et al. (2018). Detecting spacecraft anomalies using LSTMs and nonparametric dynamic thresholding.
[3] Malhotra et al. (2015). Long short term memory networks for anomaly detection in time series.