CBPF
Centro Brasileiro de Pesquisas Físicas

FAPERJ
Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro

KILONOVA SPECTROSCOPIC IDENTIFICATION USING DEEP LEARNING

Mariana S. Bittencourt,
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KILONOVAE

Transients resulting from the collision between neutron stars or between a neutron star and a black hole in compact binary systems.

The only object with an eletromagnetic counterpart to a gravitational wave event **(GW170817)**

BIG DATA

LSST (2025): about 10 million alerts per night.

How to quickly identify Kilonovae amidst so much data?

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ARTIFICIAL INTELLIGENCE

and more specifically: **DEEP LEARNING**

DATA

Spectral Energy Distributions (SED)

DATA

Spectral Energy Distributions (SED)

- **Real Supernovae's SEDs**
  - Astrocats module for the Open Supernova Catalog.
- **Simulated Kilonovae's SEDs**
  - KilonovaNet: Kilonova Surrogate Modelling.
- **SEDs of the Kilonova GW170817**

PRE-PROCESSING

- Range of wavelengths: 4000-8500 angstroms.
- Standardization at a Redshift 0.
- Interpolation of the data (200, 2).
- Normalization of the values between [0, 1].

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REAL DATA	SIMULATED DATA
• Uniform filter	• Noise addition

THE NETWORK

Sequential data

RECURRENT NEURAL NETWORK (RNN)

Sequential data

RECURRENT NEURAL NETWORK (RNN)

Long-short-term memory (LSTM) RNN

solves the vanishing gradient problem of others RNN

Bidirectional layer

process the sequence in opposite directions.

Monthly Notices
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Deep learning Blazar classification based on multifrequency spectral energy distribution data

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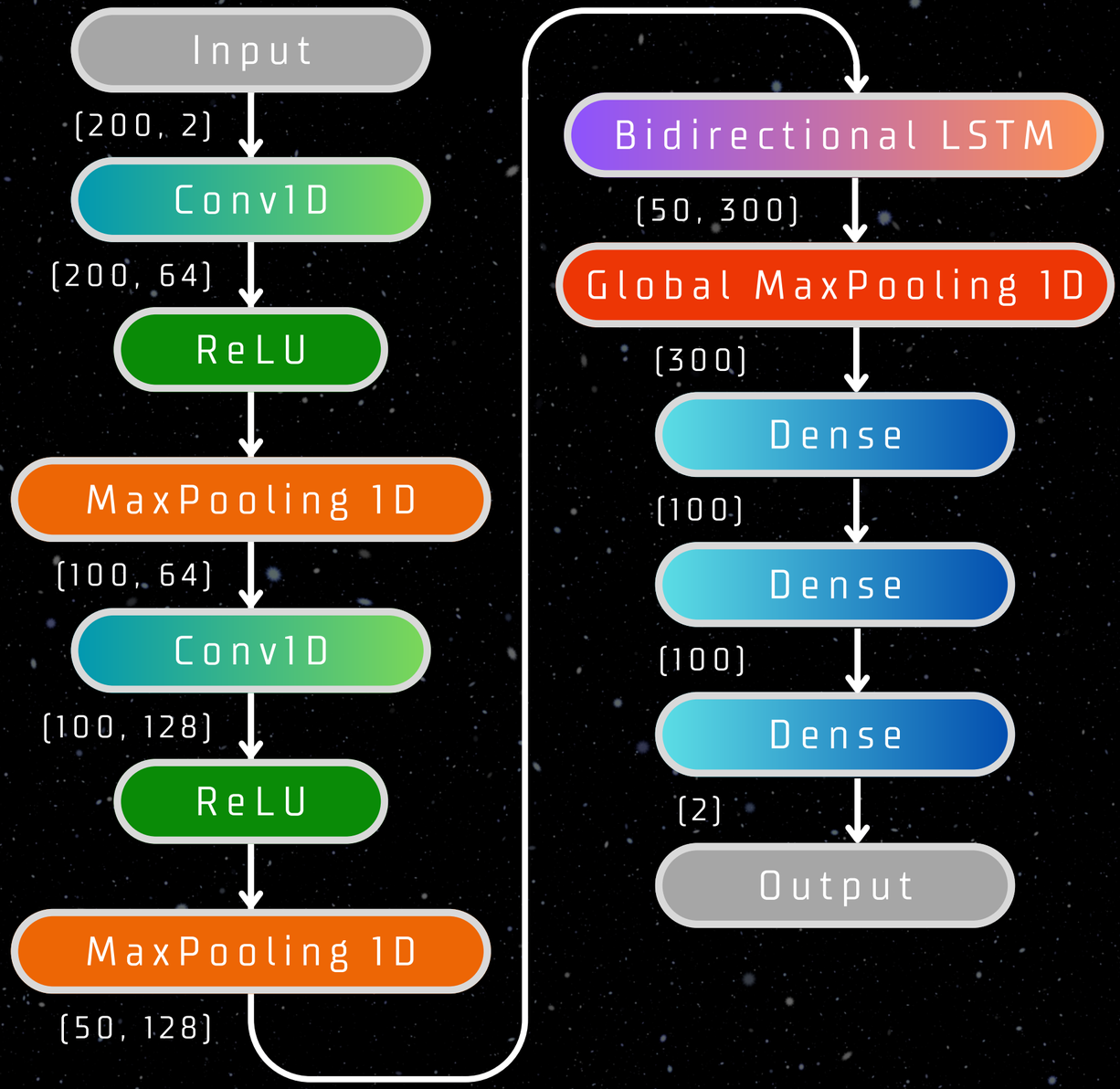
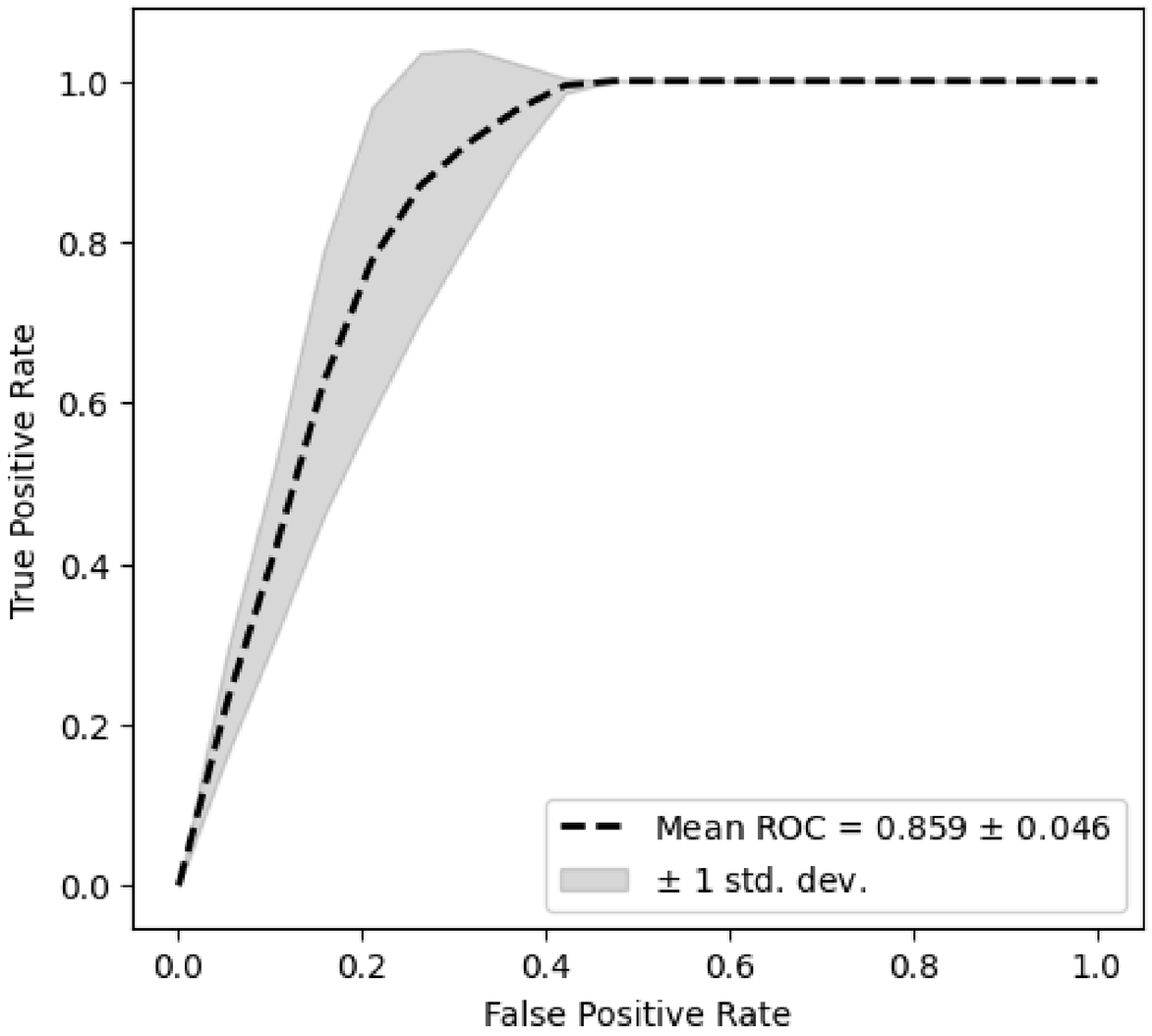
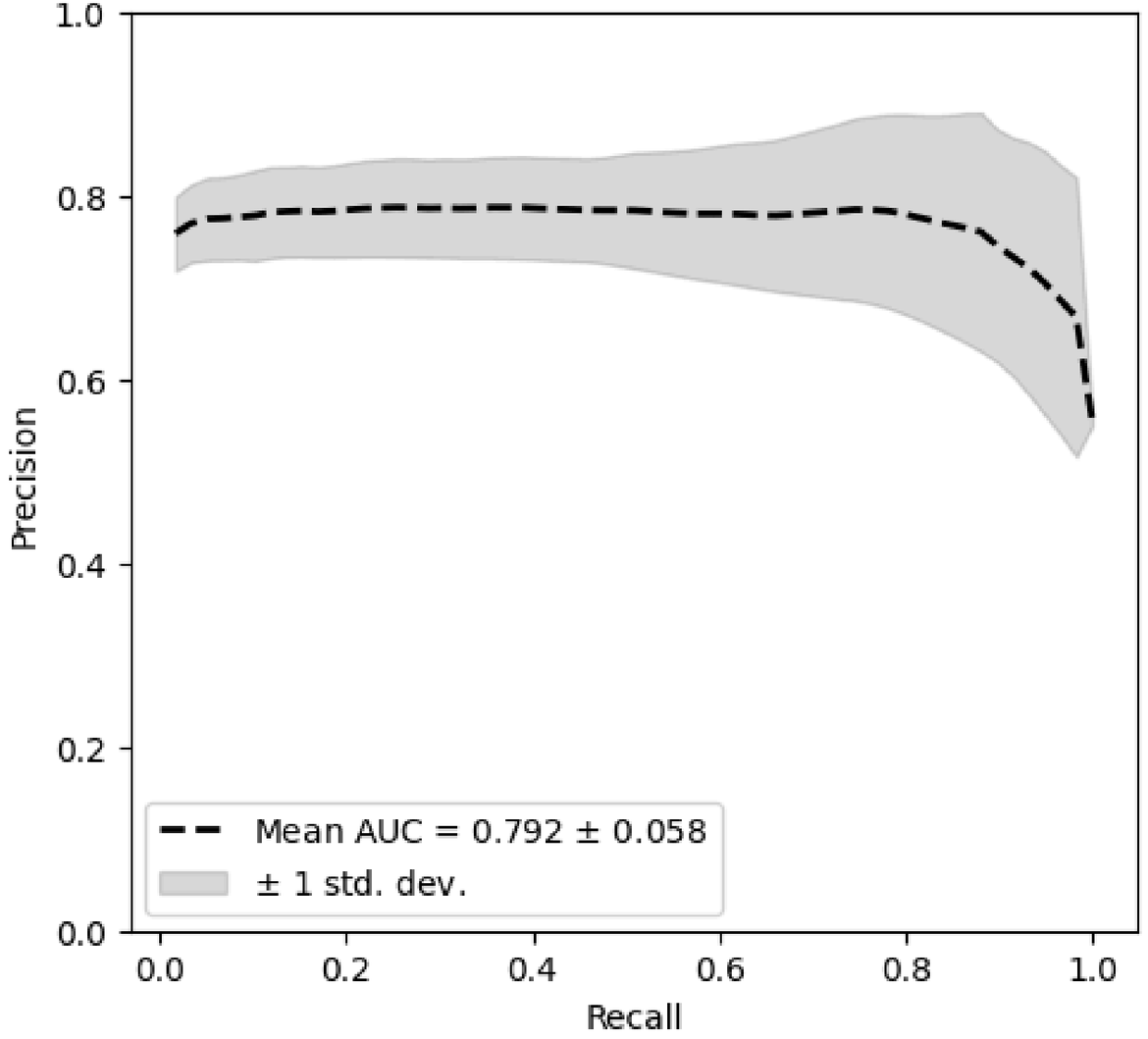
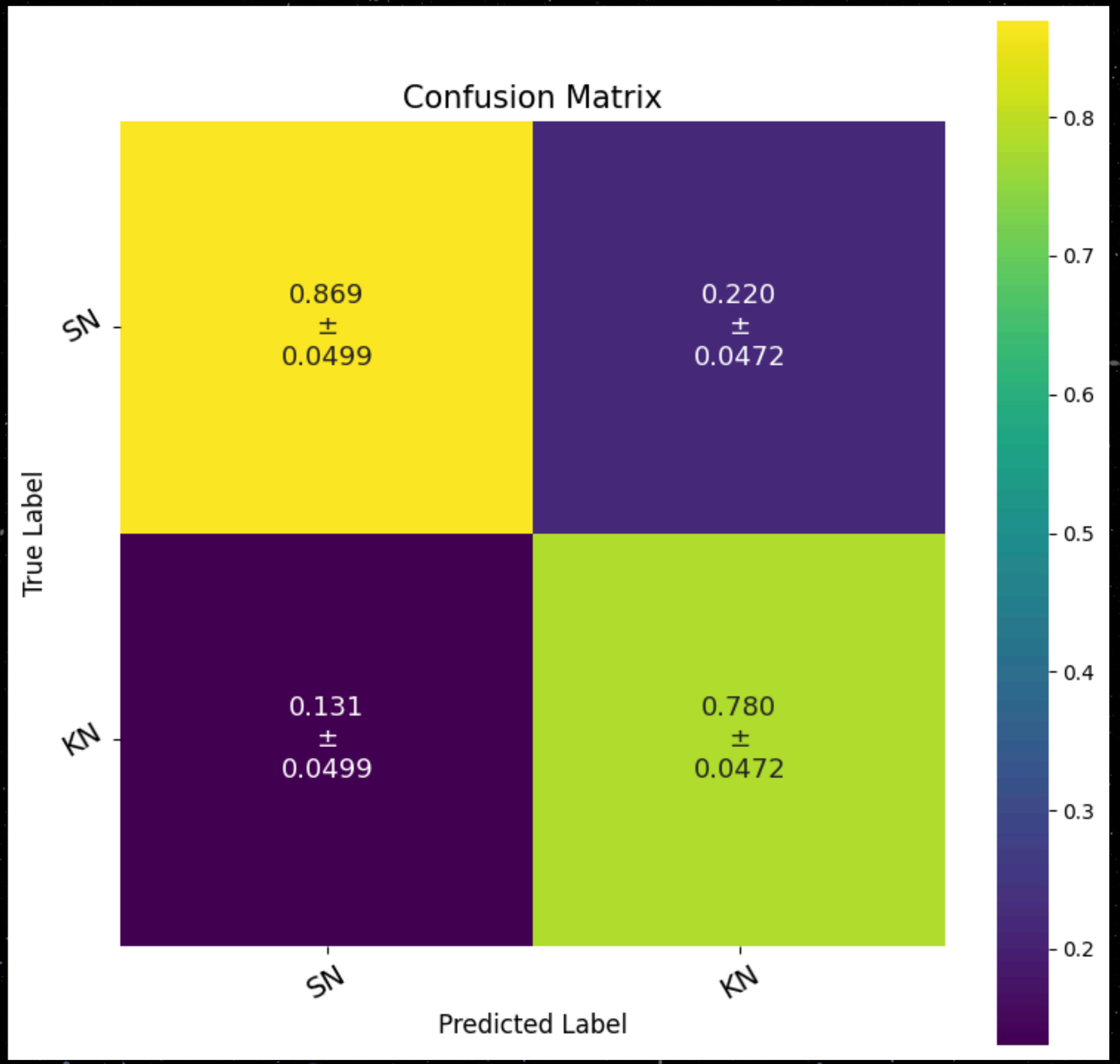

Input
(200, 2)
Conv1D
(200, 64)
ReLU
MaxPooling 1D
(100, 64)
Conv1D
(100, 128)
ReLU
MaxPooling 1D
(50, 128)
Bidirectional LSTM
(50, 300)
Global MaxPooling 1D
(300)
Dense
(100)
Dense
(100)
Dense
(2)
Output

THE NET

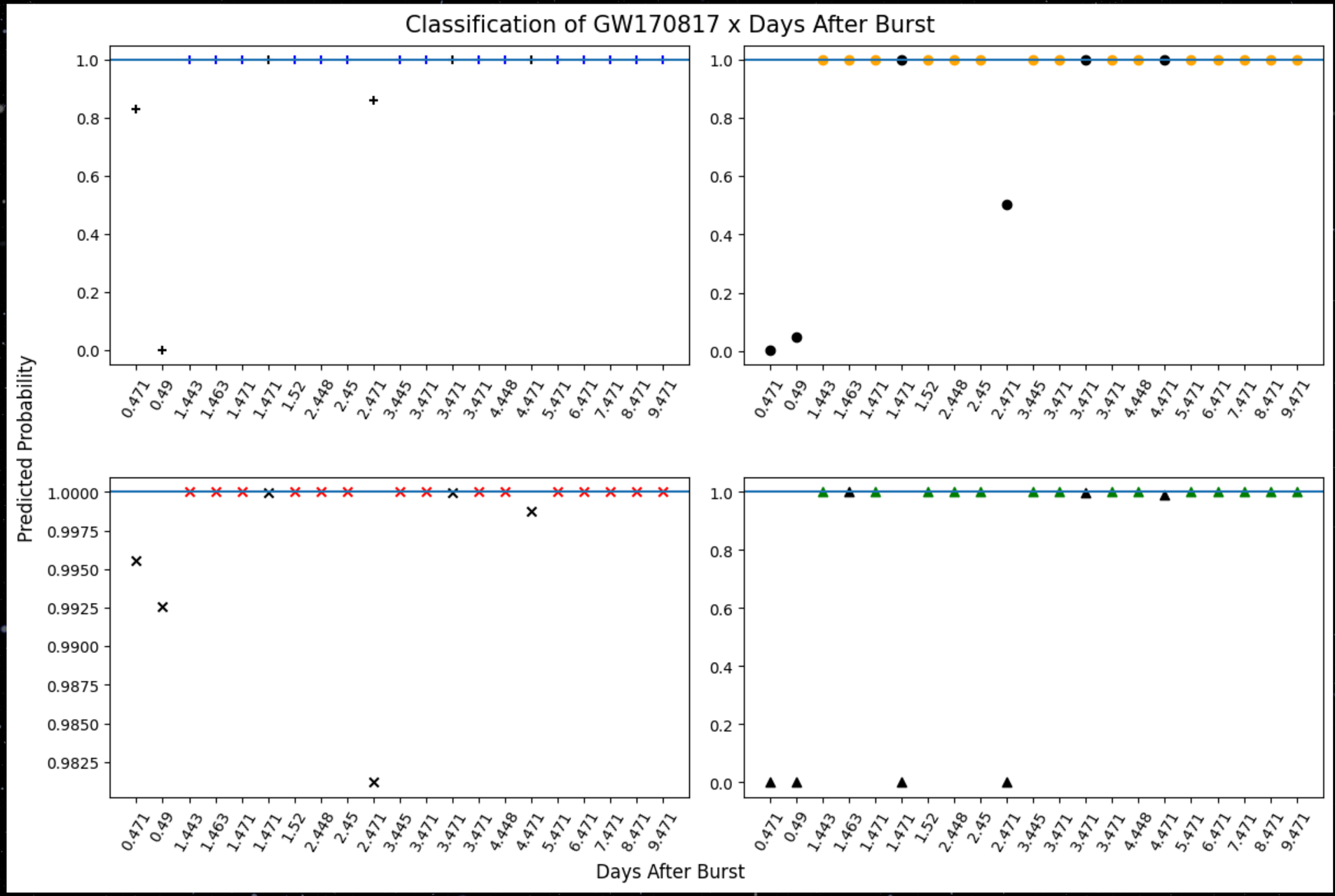
RESULTS


ROC Curve
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
Mean ROC = 0.859 ± 0.046
± 1 std. dev.


Precision Recall
Precision
Recall
0.0
0.2
0.4
0.6
0.8
1.0
Mean AUC = 0.792 ± 0.058
± 1 std. dev.


Confusion Matrix
0.869
±
0.0499
0.220
±
0.0472
0.131
±
0.0499
0.780
±
0.0472
SN
KN
True Label
SN
KN
Predicted Label
0.8
0.7
0.6
0.5
0.4
0.3
0.2

RESULTS


Classification of GW170817 x Days After Burst
Predicted Probability
Days After Burst
0.471
0.49
1.443
1.463
1.471
1.471
1.52
2.448
2.45
2.471
3.445
3.471
3.471
3.471
4.448
4.471
5.471
6.471
7.471
8.471
9.471

CONCLUSION

Based on the consistency of the results obtained and the methodology used, we intend to focus on refining the network, with a view to the application of this analysis as an observational follow-up tool for the next Observing Runs of the LIGO-Virgo-KAGRA, using data from observatories such as LSST for classifying these transients in search of multi-messenger data.

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THANK YOU!

OBRIGADA!

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