

Time Series Machine Learning with *aeon*

Inria P16 Days

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October 14, 2025



P16

Communs numériques
pour une IA souveraine

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1. **Introduction: Time Series Machine Learning**

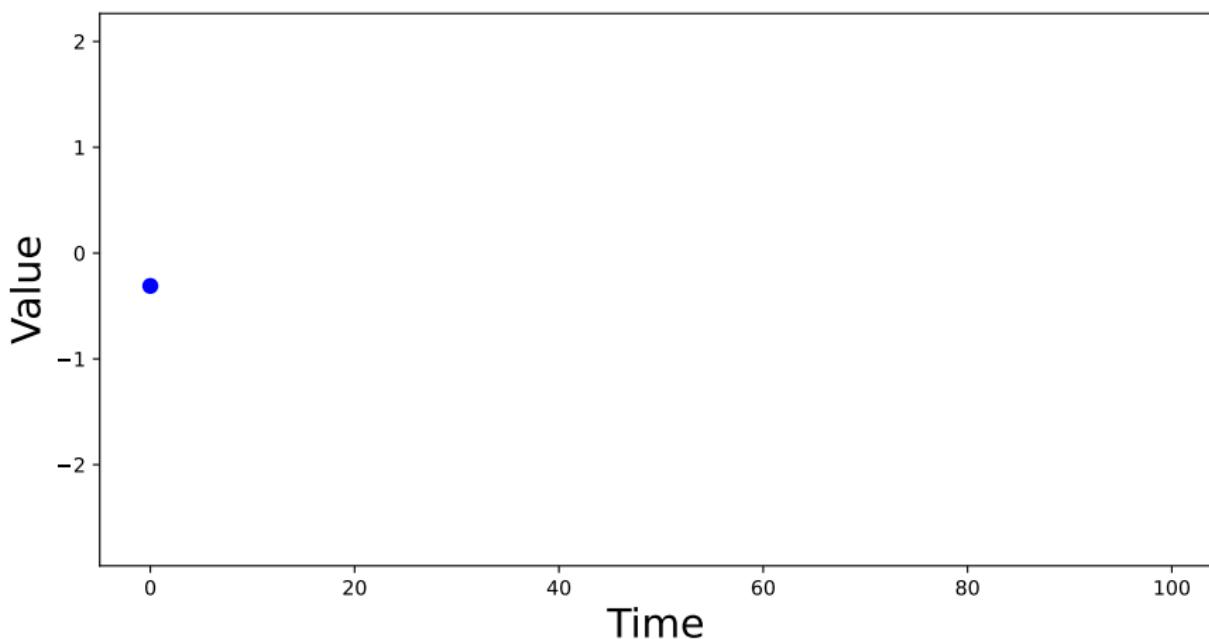
2. Overview on *aeon*: Team & History

3. *aeon* Package

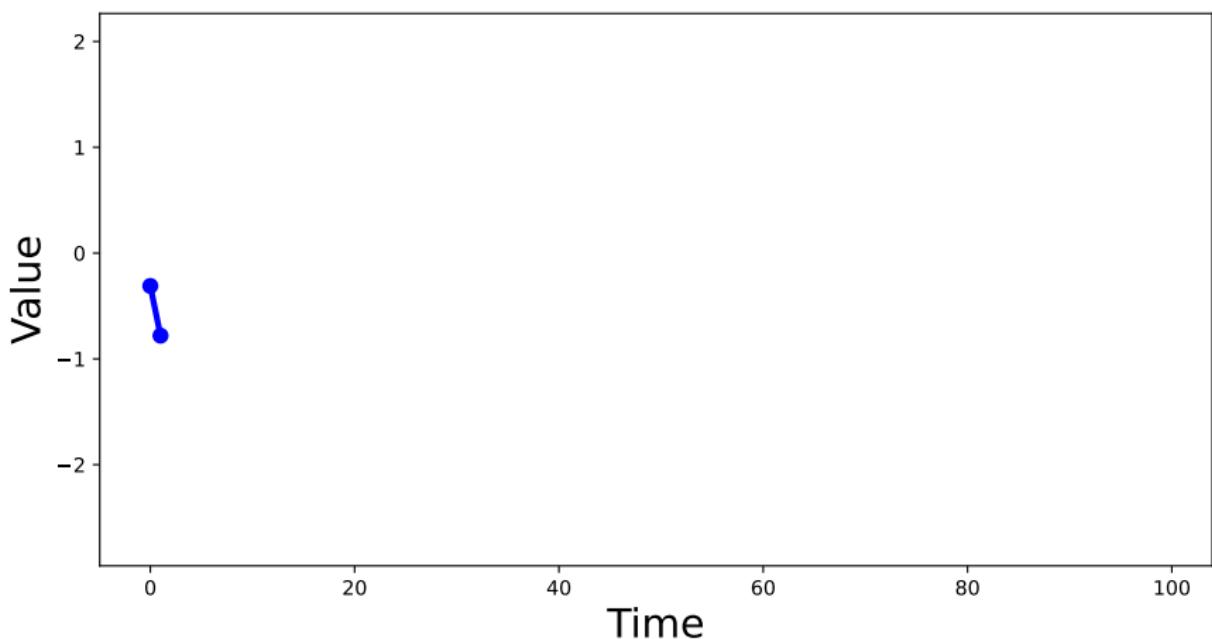
4. *aeon's* Deep Learning Side

5. *aeon's* Roadmap

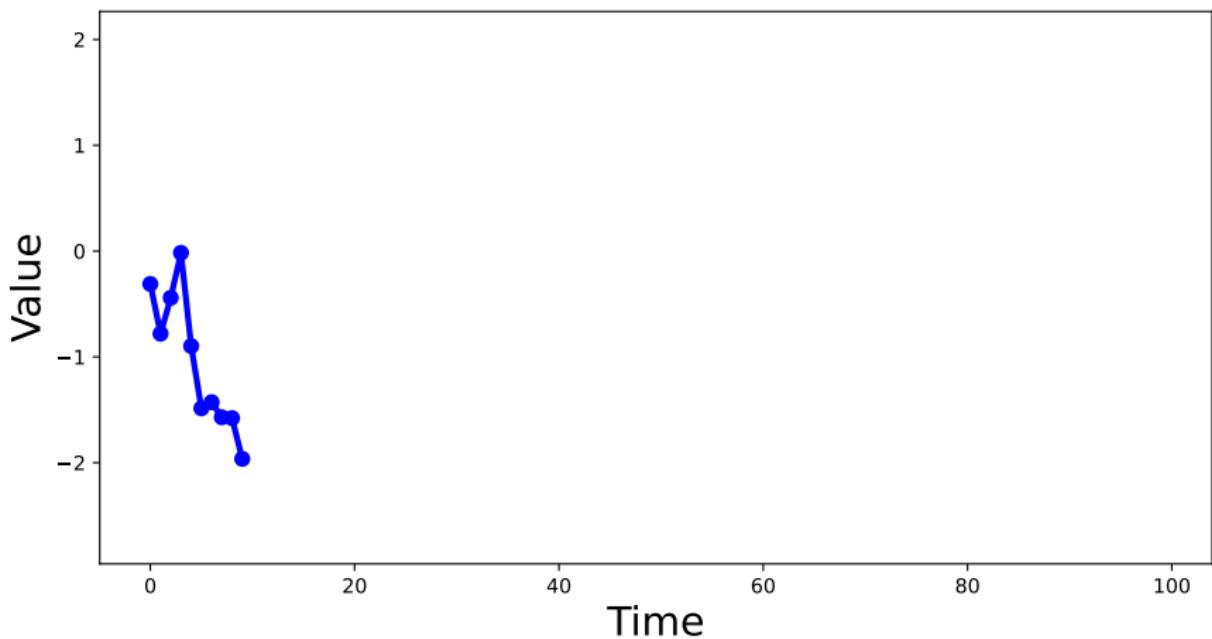
Time Series Data



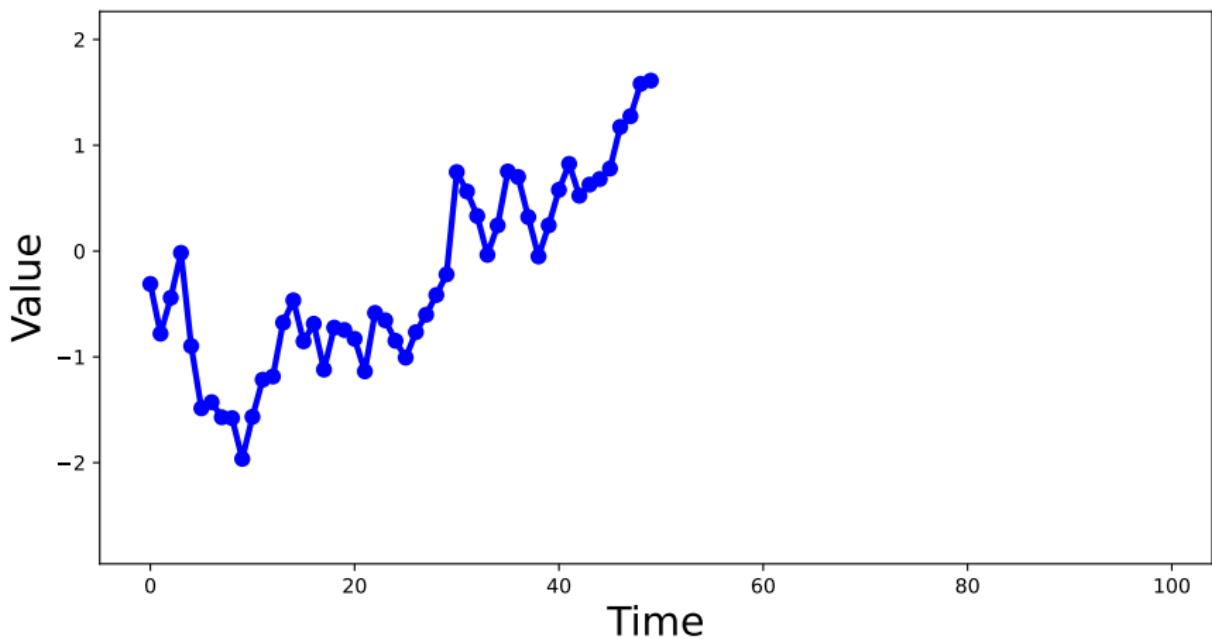
Time Series Data



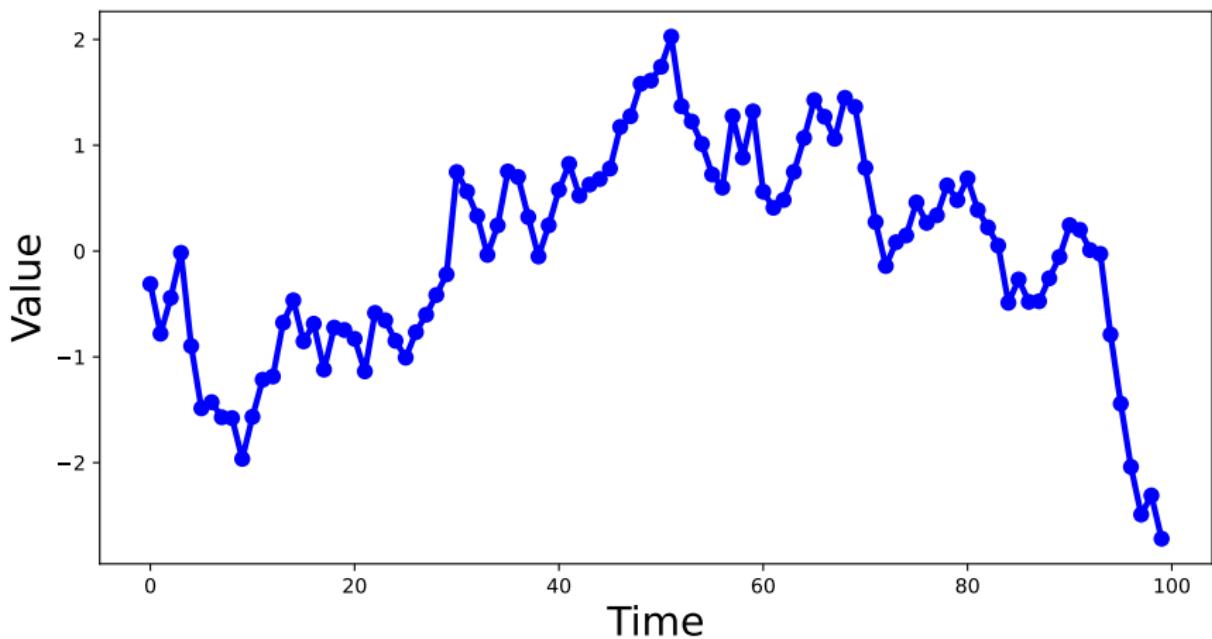
Time Series Data



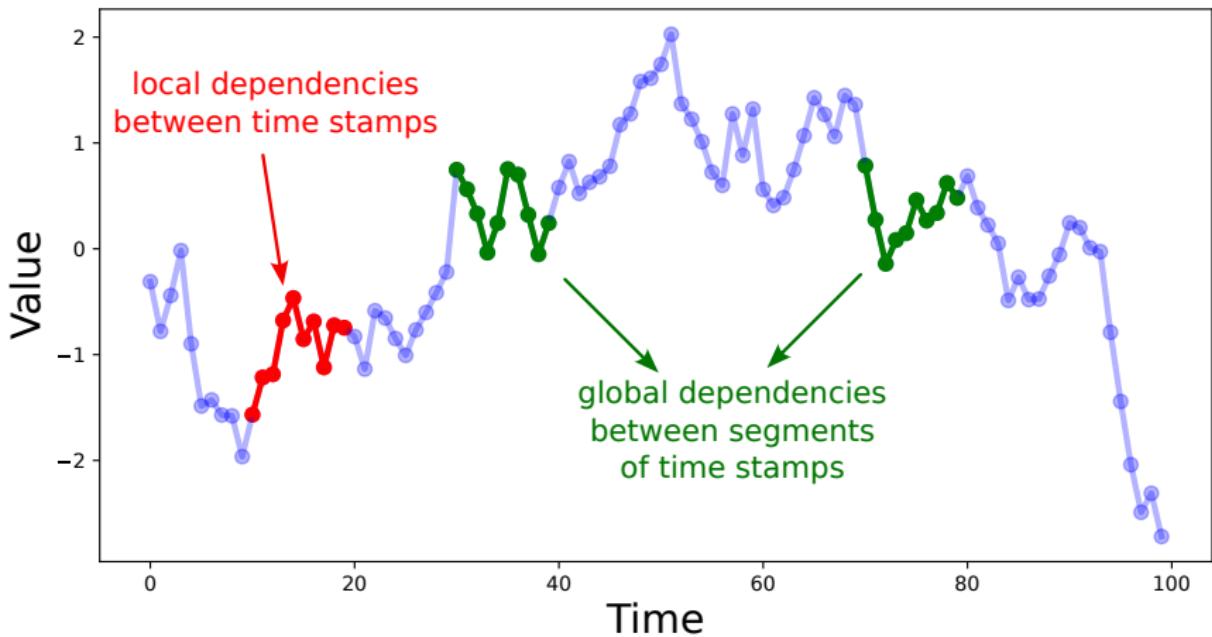
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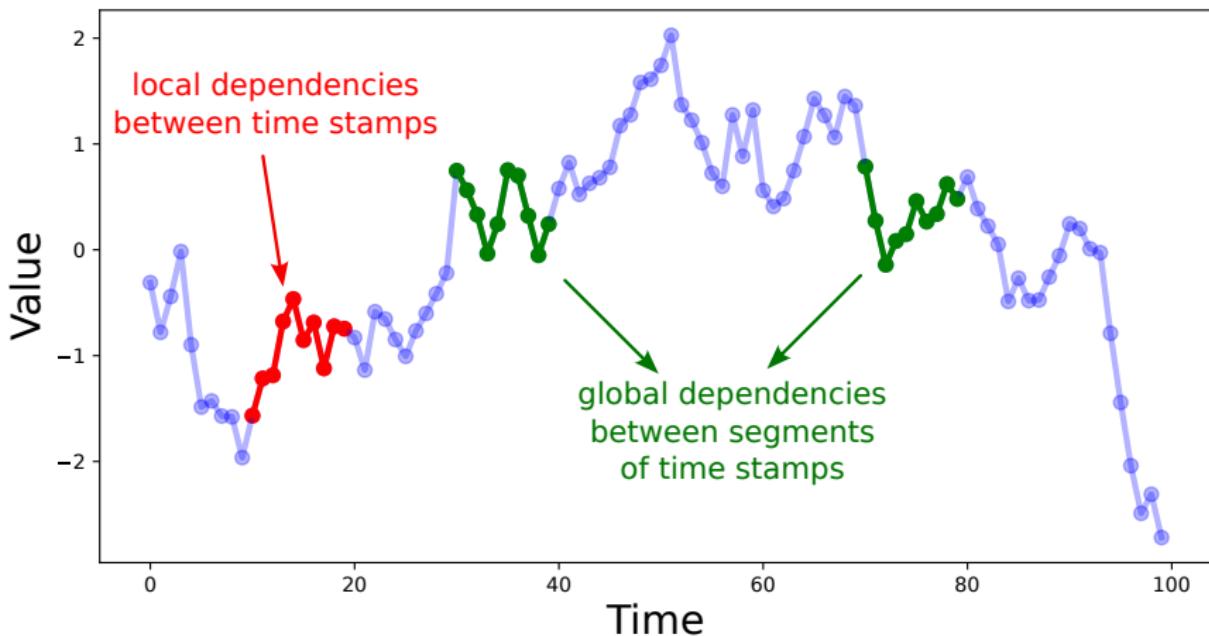
Time Series Data



Time Series Data

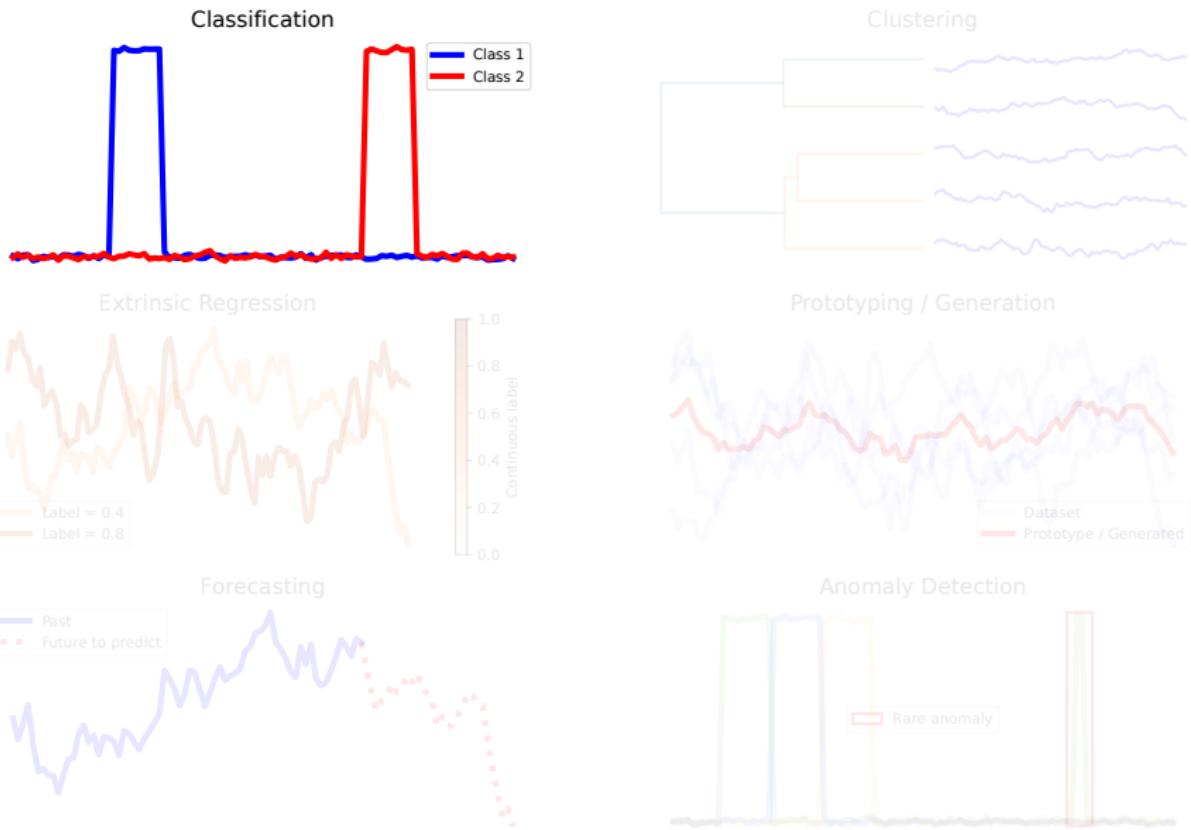


Time Series Data

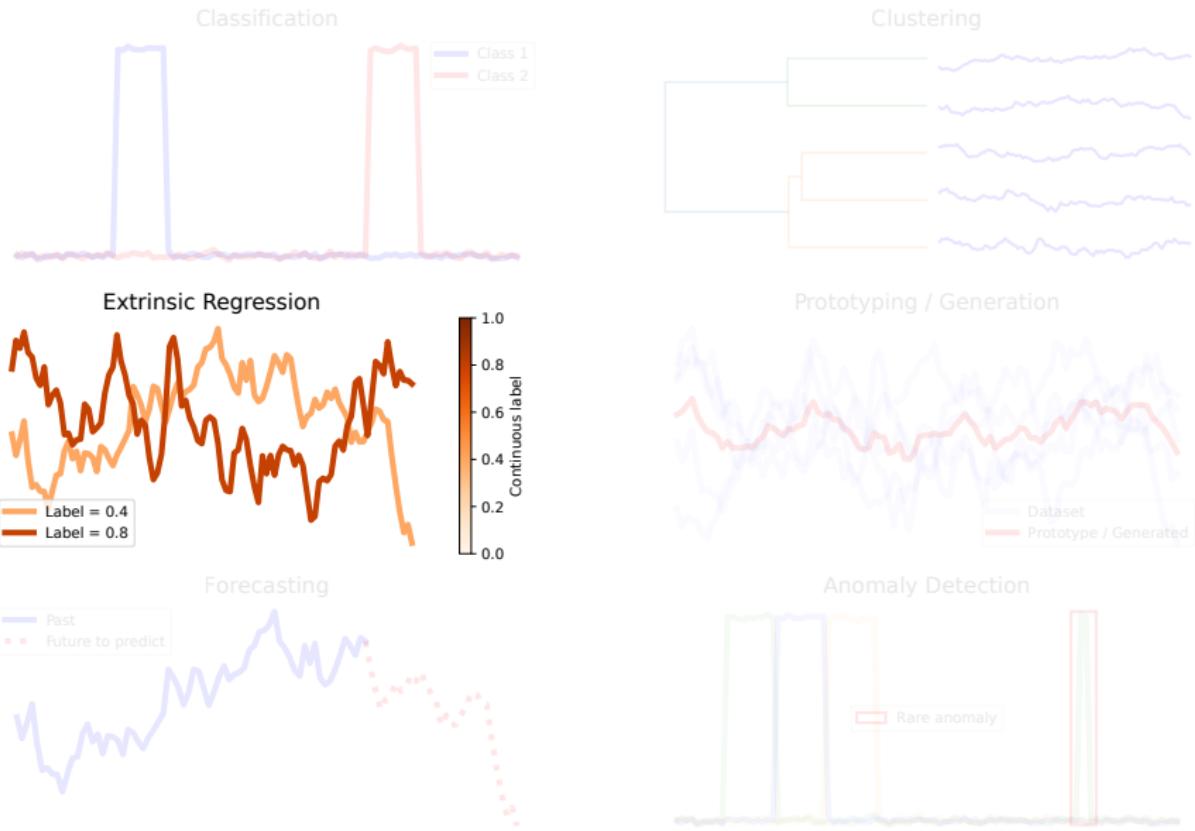


- Any kind of ordered data can be considered as time series
- Time series machine learning: classification, clustering, extrinsic regression, forecasting, anomaly detection etc.

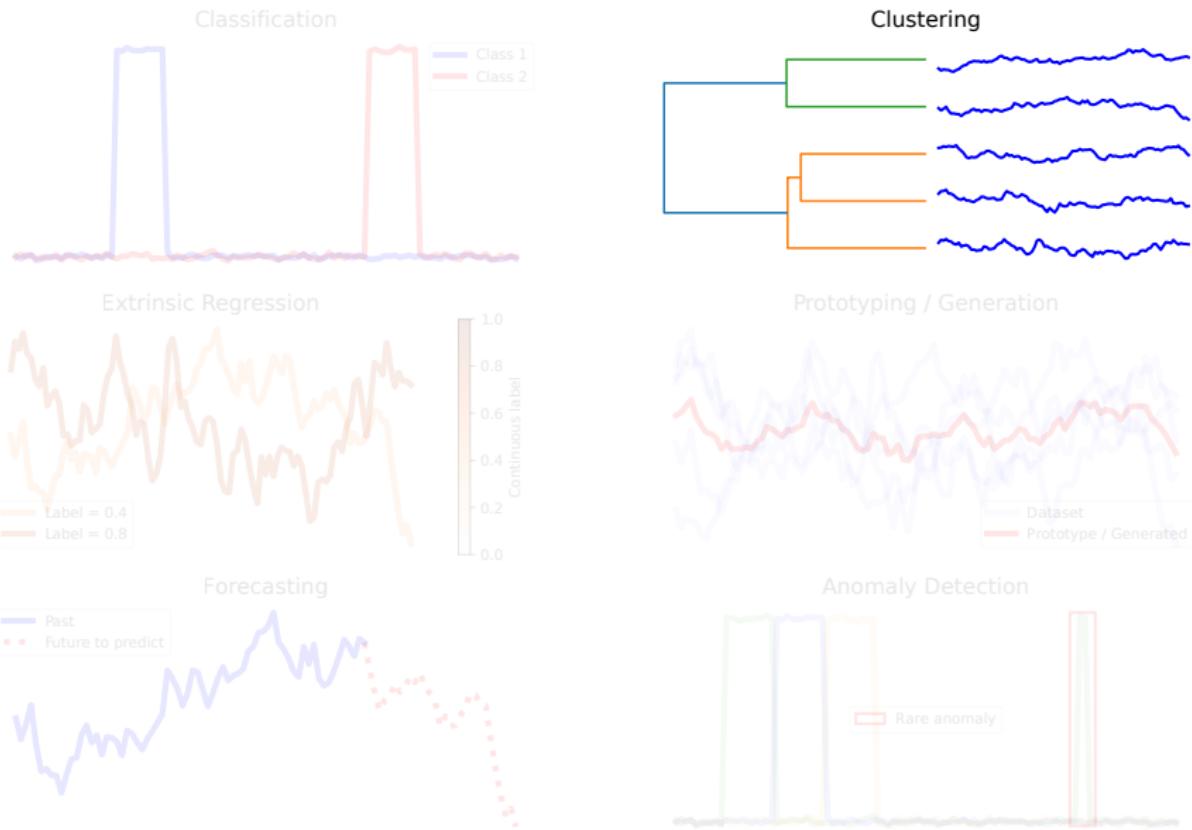
Time Series Machine Learning (TSML)



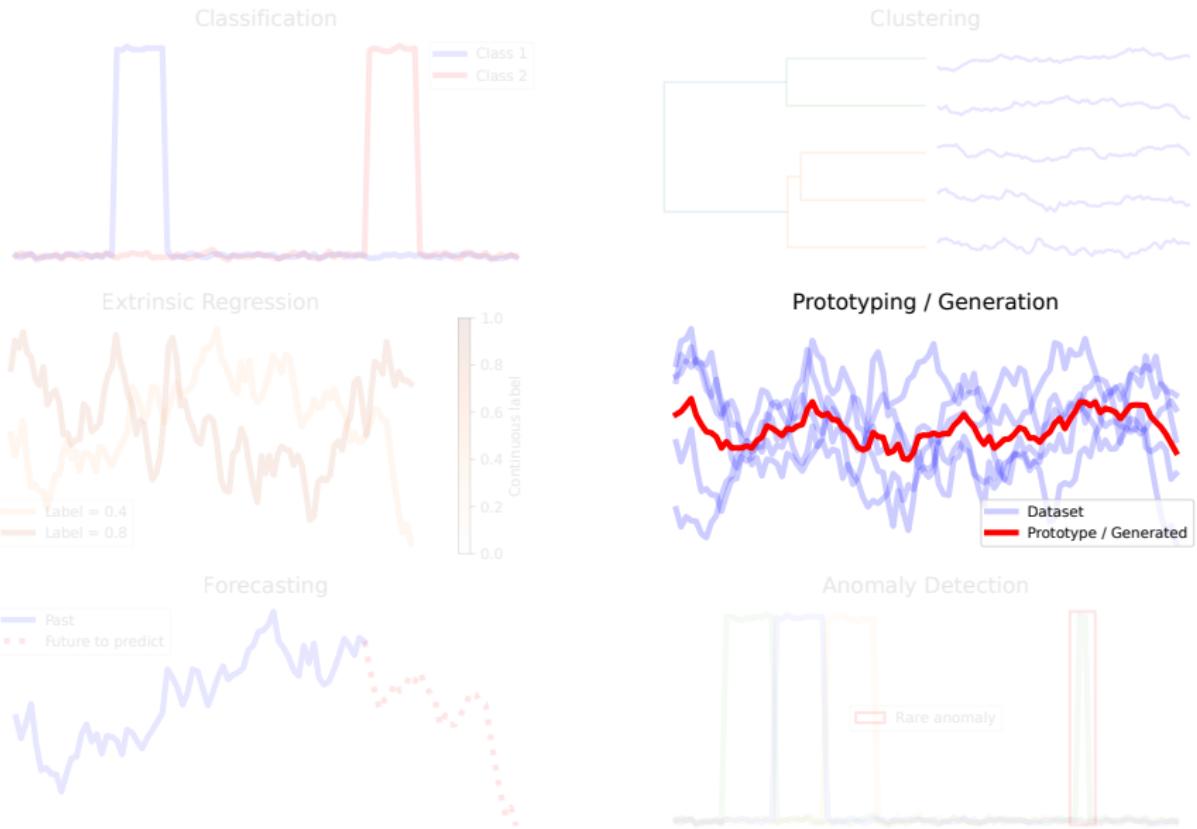
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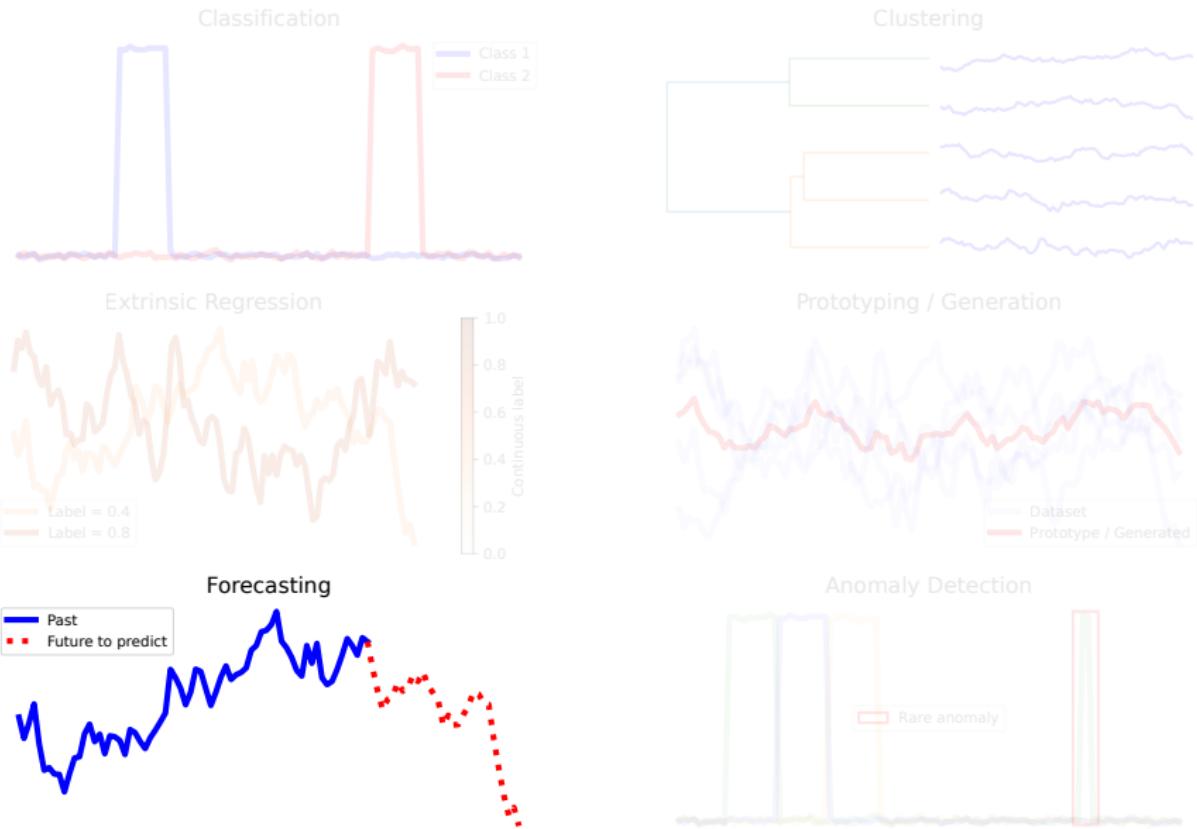
Time Series Machine Learning (TSML)



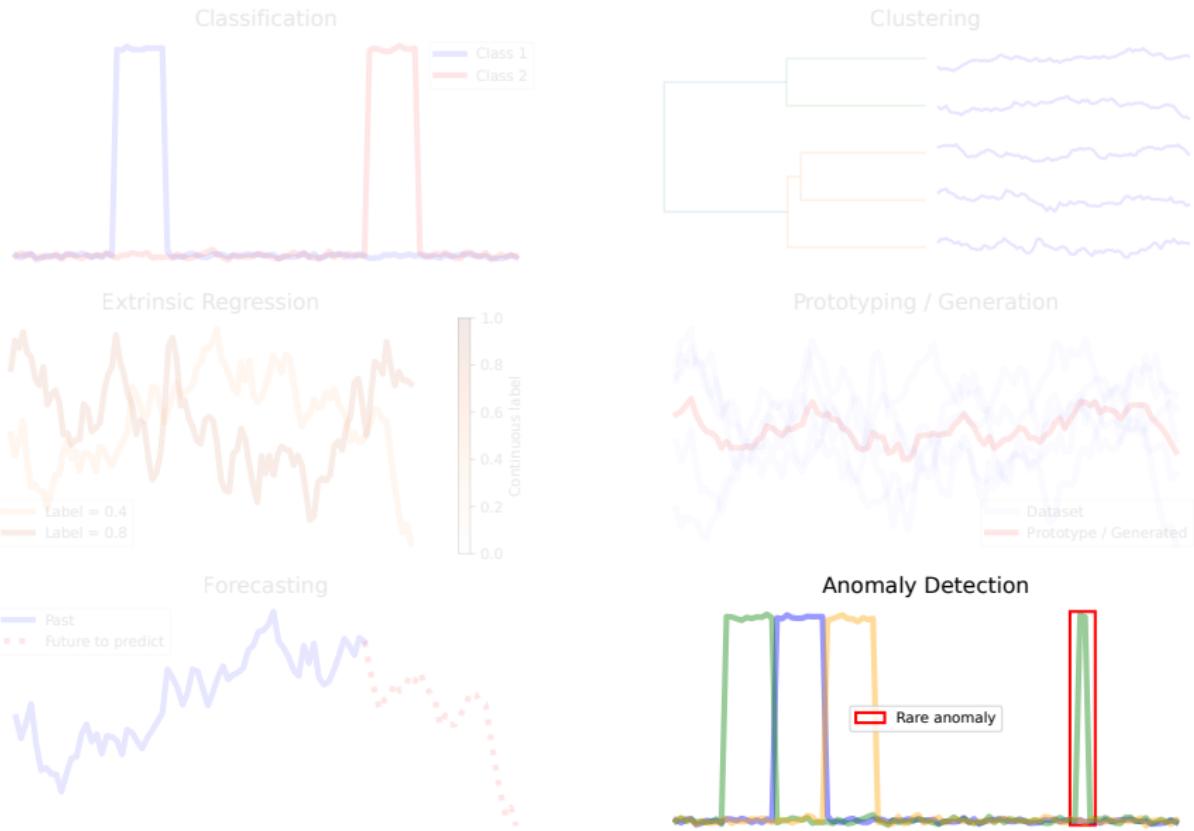
Time Series Machine Learning (TSMIL)



Time Series Machine Learning (TSML)



Time Series Machine Learning (TSML)



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The aeon Dream Team



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Bagnall



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Schäfer



Microsoft

Divya
Tiwari



Aadya
Chinubhai



The aeon Dream Team



An Introduction to Machine Learning from Time Series

An ECML PKDD 2024 Tutorial in association with AALTD 2024

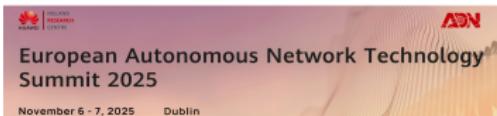
PyData Amsterdam 2023



IIF Workshop on Open Source Forecasting

25th-27th June 2025

Venue: Beihang University, Haidian District, Beijing, China

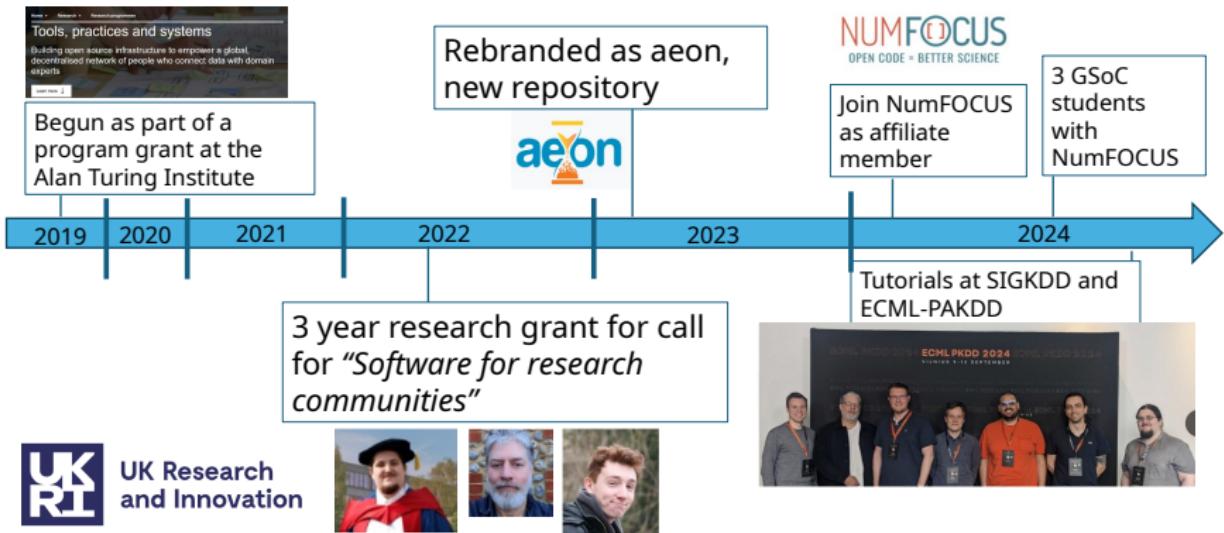


10th Workshop on Advanced Analytics and Learning on Temporal Data (AALTD 2025)

AALTD is an ECML / PKDD 2025 workshop

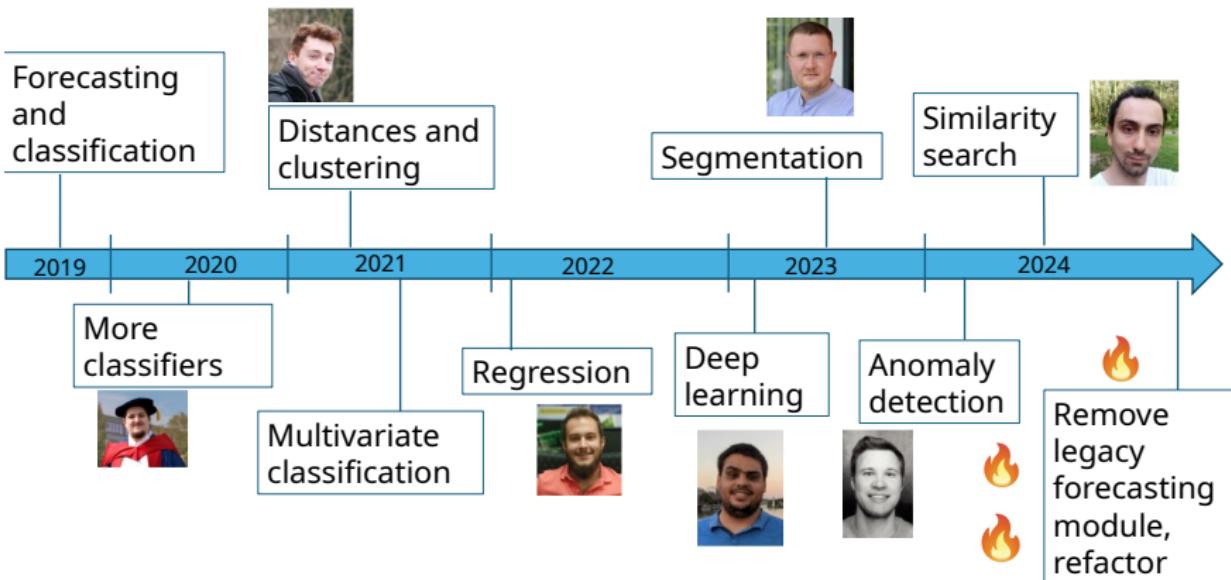
History

General View (2019-2024)



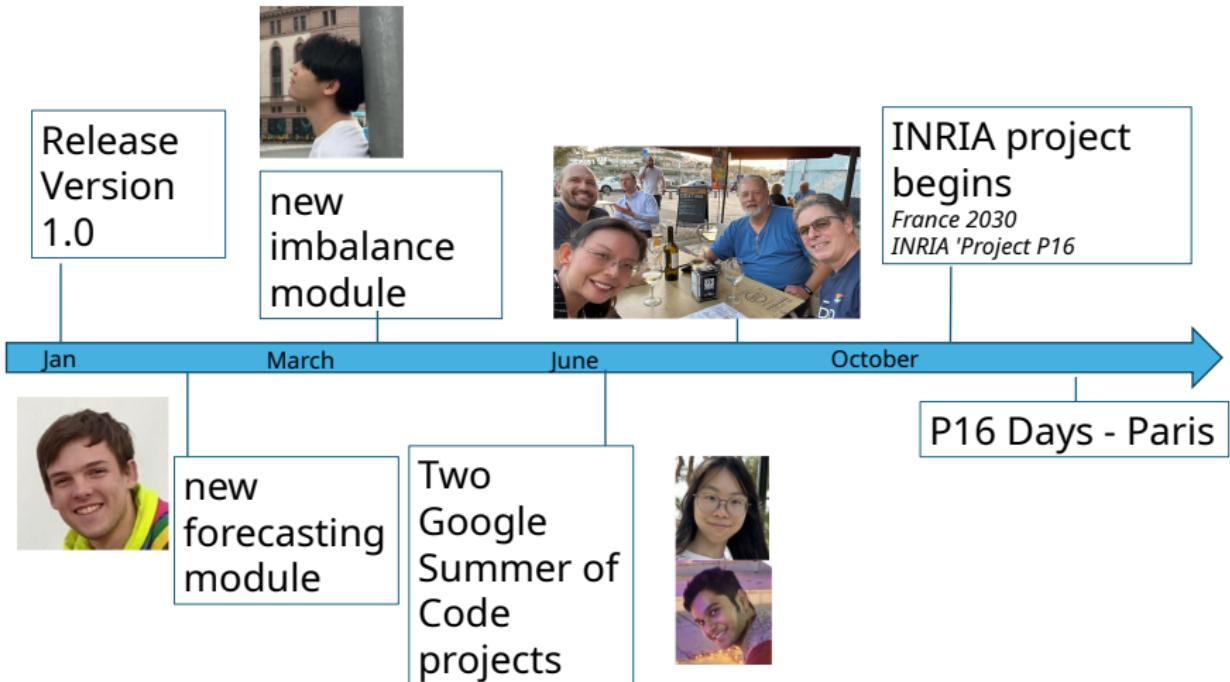
History

Closer Look (2019-2024)



History

More Recently



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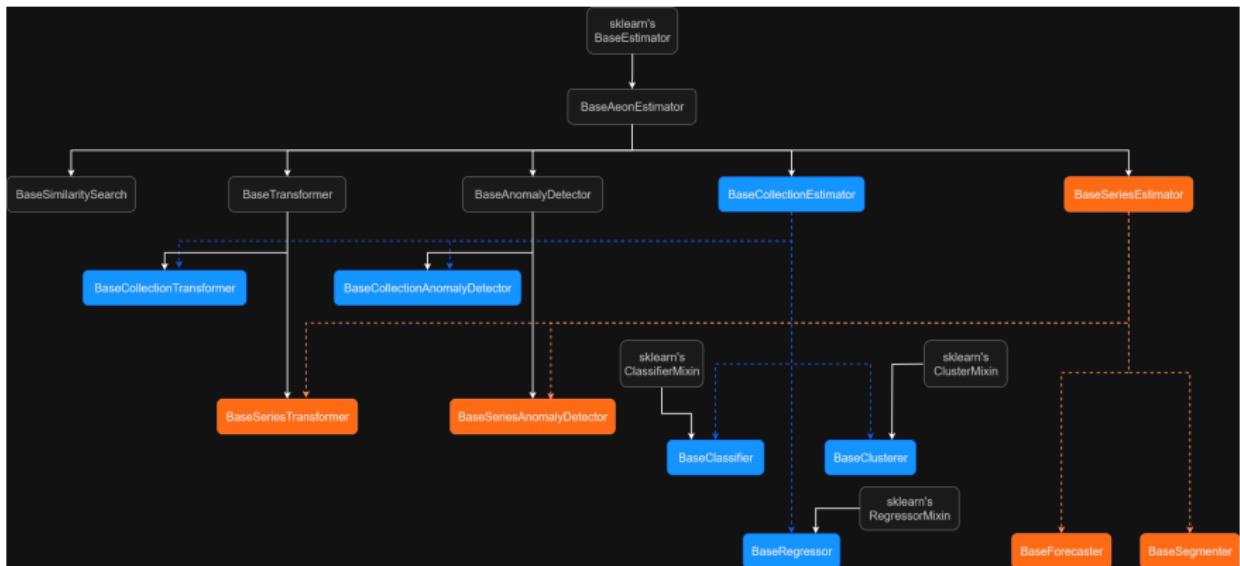
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aeon: An *sklearn* compatible Python tool for TSML

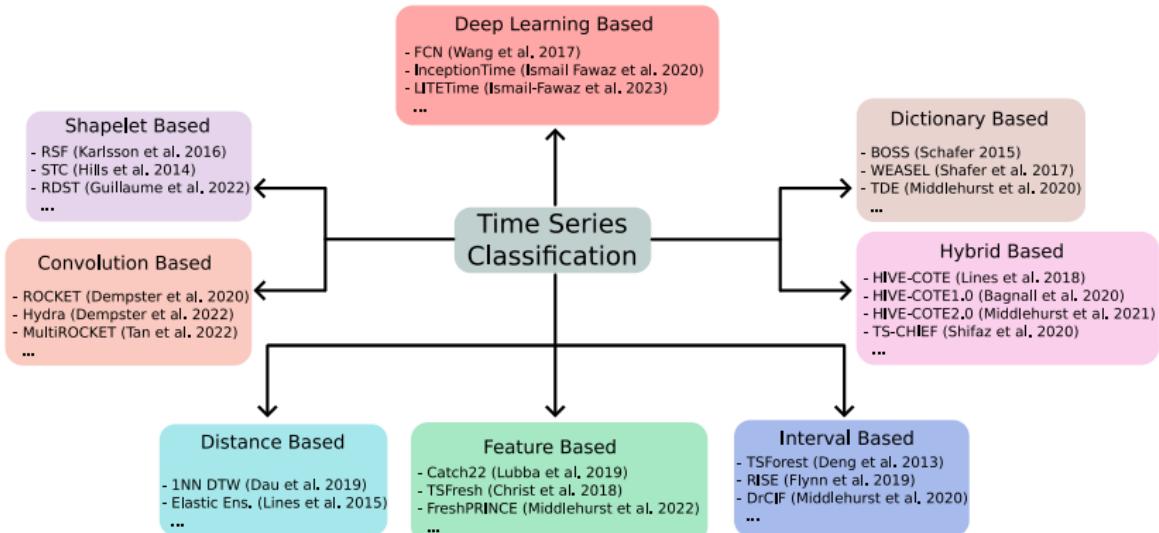


Middlehurst, M., Ismail-Fawaz, A., Guillaume, A., Holder, C., Guijo-Rubio, D., Bulatova, G., Tsaprounis, L., Mentel, L., Walter, M., Schäfer, P. and Bagnall, A., 2024. aeon: a Python toolkit for learning from time series. *Journal of Machine Learning Research*, 25(289), pp.1-10.

aeon Base Structure



Example Structure for Classification



Middlehurst, M., Schäfer, P., & Bagnall, A. (2024). Bake off redux: a review and experimental evaluation of recent time series classification algorithms. *Data Mining and Knowledge Discovery*, 1-74.

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Deep Learning in aeon

Classification
10 models

Networks
20 models

Regression
11 models

Clustering
6 models

Deep Learning
in aeon

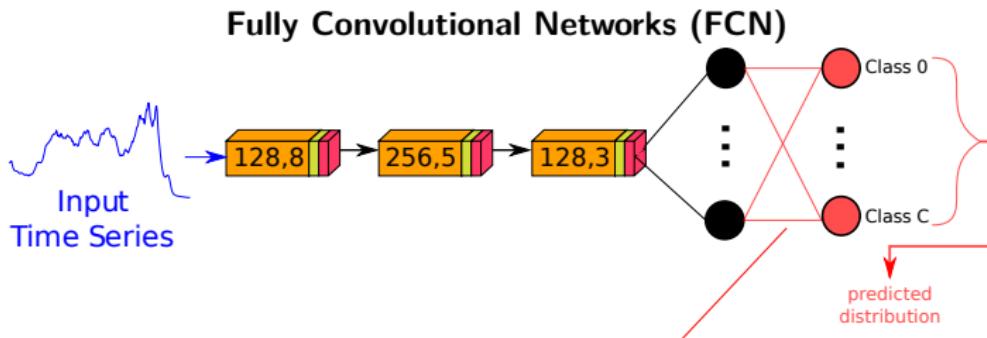
Forecasting
2 models

Self-Supervised
2 models

Forecasting and Self-Supervised are still experimental

Deep Learning for Time Series Classification

 : 1D convolution layer with n filters of size k.  : batch normalization.  : activation
— : fully Connected. — : 1D global average pooling

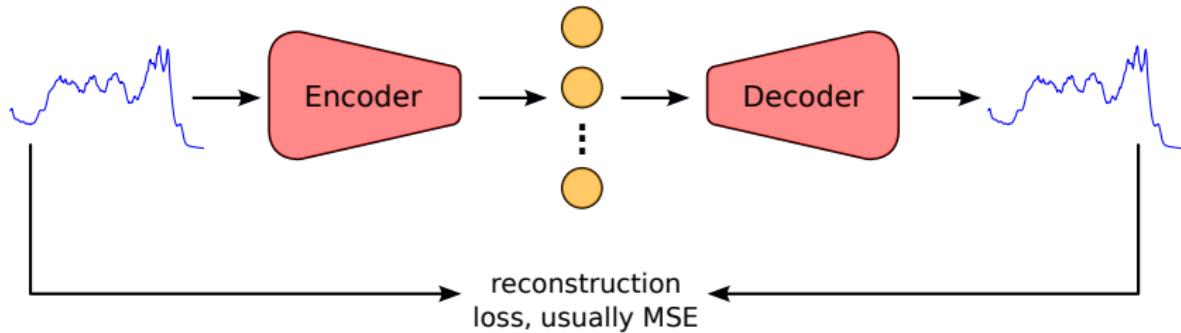


Wang, Z., Yan, W., & Oates, T. (2017, May). Time series classification from scratch with deep neural networks: A strong baseline. In 2017 International joint conference on neural networks (IJCNN) (pp. 1578-1585). IEEE.

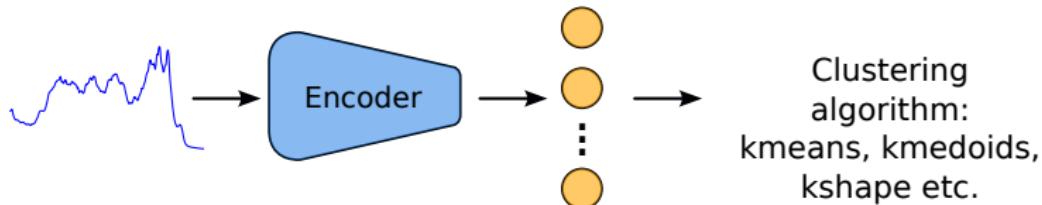
Deep Learning for Time Series Clustering

Auto-Encoder based method:

Pre-training:



Clustering Downstream Task:

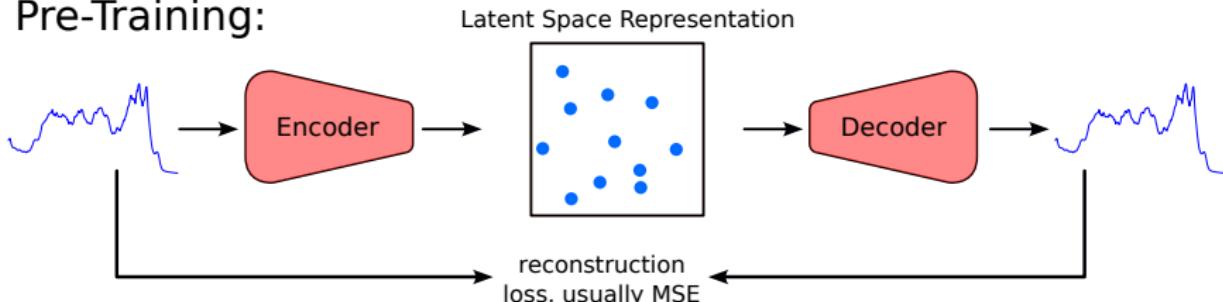


- Lafabregue, Baptiste, et al. "End-to-end deep representation learning for time series clustering: a comparative study." *Data Mining and Knowledge Discovery* 2022.

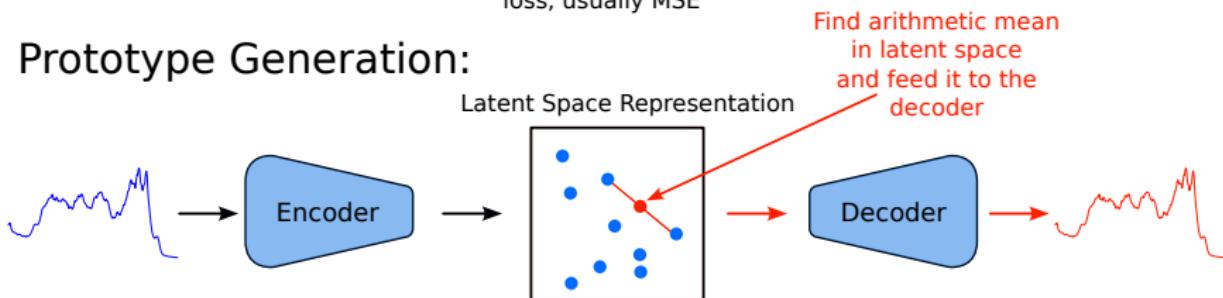
Deep Learning for Time Series Prototyping Generation

Auto-Encoder based approach with latent space mean selection:

Pre-Training:



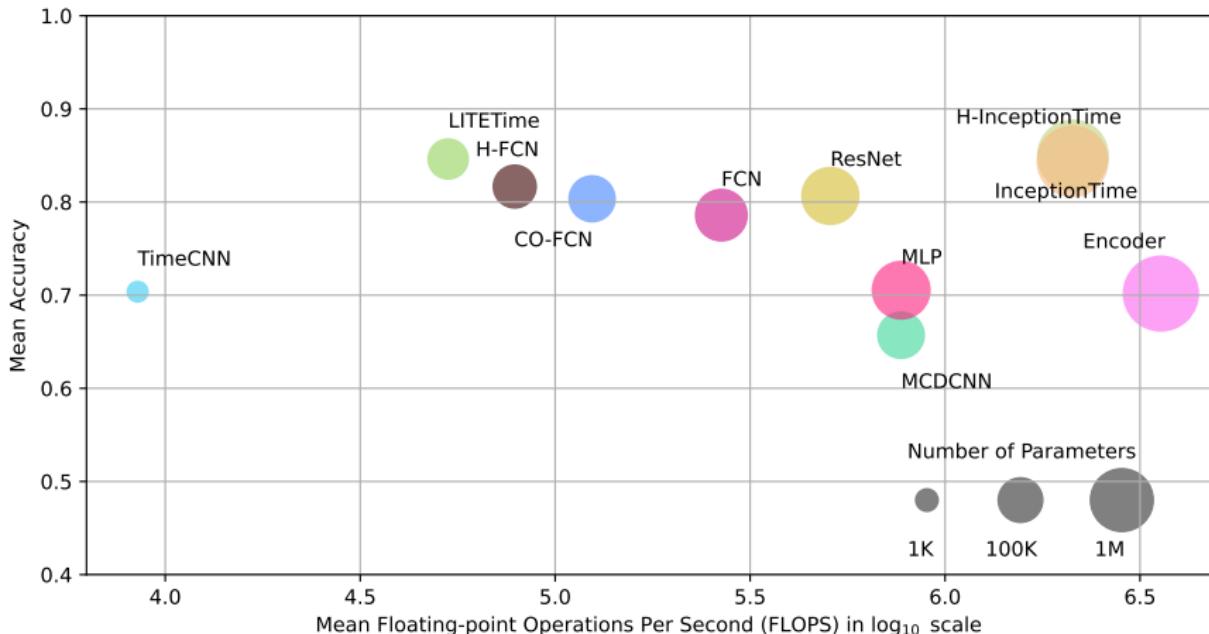
Prototype Generation:



- Terefe, Tsegamlak, et al. "Time series averaging using multi-tasking autoencoder." *IEEE 32nd International Conference on Tools with Artificial Intelligence (ICTAI)* 2020.
- Terefe, Tsegamlak, et al. "Estimating time series averages from latent space of multi-tasking neural networks." *Knowledge and Information Systems* 2023.

Comparing all the architectures for univariate datasets

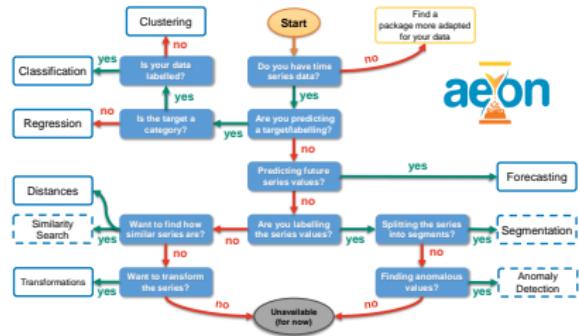
We created a dynamic website (updated regularly) to compare all these architectures in terms of performance and complexity:



Try it out on : <https://msd-irimas.github.io/pages/dl4tsc/>

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- Time Series Machine Learning with **aeon**
- Current focus is **Forecasting** with statistical models, machine learning models (SETAR) and deep learning models
- Adding more utility of deep learning into other tasks: anomaly detection, averaging, segmentation
- Integration **Self-Supervised** models into unsupervised tasks (e.g. **Clustering**)
- Our goal: Reproducible research, pushing towards full open-source, optimized code for deployment
- Website: <https://hadifawaz1999.github.io/>
- Contact: ali-el-hadi.ismail-fawaz@uha.fr