

EBUL: Event-based Unsupervised Learning for Physiological Signals

Thomas Moreau Inria Saclay

ANR JCJC – 2023



General Anesthesia Monitoring

IntelliVue

ECG

Indicators

Pleth.

Resp.

EEG

58

97

103/48 (68)

12

35

62

30

35.8

Perf 5.8
PVI 4.80
PVI 3
VPP 5

O₂-f_e 25
O₂-In 32

MAC 0.0

RS 30

NMT

113/63 (73)

PHILIPS



MX850

General Anesthesia Monitoring

IntelliVue

ECG

Indicators

Pleth.

Resp.

EEG

Find predictive representations
of multivariate signals
using AI.

58

97

2

35

62

30

35.8

03/48 (68)

25

32

MAC 0.0

RS 30

Recent breakthrough in AI: Foundation Models



ChatGPT



Midjourney

What do they have in common?

Recent breakthrough in AI: Foundation Models



ChatGPT



Midjourney

What do they have in common?

Tokens

Self-supervised pretraining

Capture the input distribution $\mathbb{P}(X)$ with interaction between tokens.

Recent breakthrough in AI: Foundation Models



ChatGPT



Midjourney

What do they have in common?

Tokens

Self-supervised pretraining

Capture the input distribution $\mathbb{P}(X)$ with interaction between tokens.

Challenges for signals:

- ▶ What are the tokens of the signals?
- ▶ How to derive more interpretable models?

Signals' Tokens: Events

IntelliVue

Observed events

Drug injection

Surgery acts

Adverse outcomes

Stimulus



Signals' Tokens: Events

IntelliVue

Observed events

Latent events

Drug injection

Heartbeat

Surgery acts

Dichrote wave

Adverse outcomes

Breath Cycle

Stimulus

Brain waves



Début/Arrêt PNI

Zéro

Régler gain

Tendances Vitales

Événement manuel

Filtre Intervention

Configur. Princip.

Autres

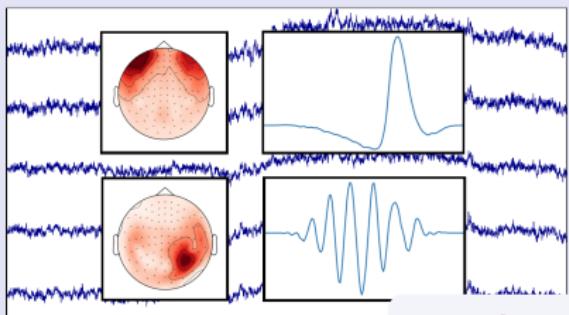
Ecran

PHILIPS



MX850

Signals' Tokens: Events



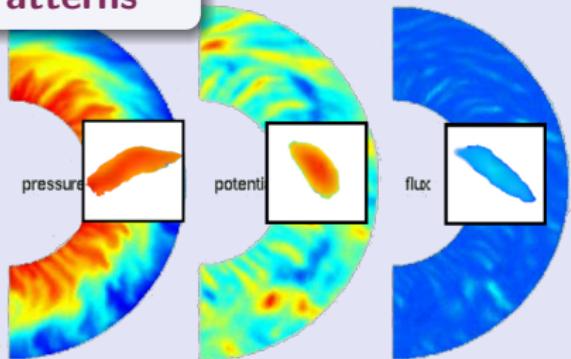
Neuroscience (N)



Latent Events
are characterized by
Recurring Patterns



Astronomy



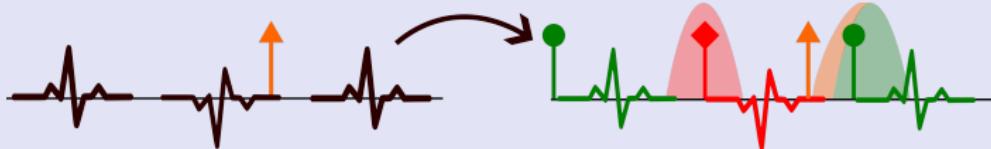
Physics Simulation

EULPS: Event-based Unsupervised Learning for Physiological Signals

EULPS Goal

Model Physiological Signals as a Distribution of Events.

Challenge: Need to infer what are the events and model their distribution jointly.

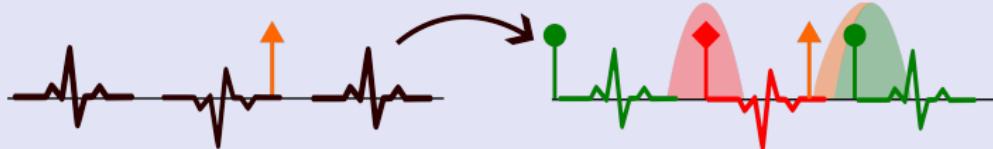


EULPS: Event-based Unsupervised Learning for Physiological Signals

EULPS Goal

Model Physiological Signals as a Distribution of Events.

Challenge: Need to infer what are the events and model their distribution jointly.



Events' distribution
models

Joint Modeling of
Signals and Events

Task-specific
Fine-tuning Algo.

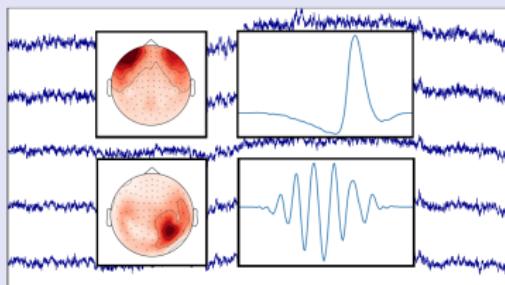
References

- [ICLR2022] Allain, C., Gramfort, A. & **Moreau, T.** *DriPP: Driven Point Process to Model Stimuli Induced Patterns in M/EEG Signals.* in ICLR 2022.
- [ICLR2022a] Malézieux, B., **Moreau, T.** & Kowalski, M. *Understanding approximate and Unrolled Dictionary Learning for Pattern Recovery.* in ICLR 2022.
- [NeurIPS2022] Dagréou, M., Ablin, P., Vaiter, S. & **Moreau, T.** *A framework for bilevel optimization that enables stochastic and global variance reduction algorithms.* in NeurIPS 2022.
- [ICML2023] Staerman, G., Allain, C., Gramfort, A. & **Moreau, T.** *FaDIn: Fast Discretized Inference for Hawkes Processes with General Parametric Kernels.* in ICML 2023.
- [NImg 2023] Power, L., Allain, C., **Moreau, T.**, Gramfort, A. & Bardouille, T. *Using convolutional dictionary learning to detect task-related neuromagnetic transients and ageing trends in a large open-access dataset.* NeuroImage 2023.

Task Table

	T-1.1 Parametric TPPs	WP1		WP2		WP3		WP4
	T-1.2 Marked PPs	T-1.3 Spatial PPs		T-2.1 Joint estimation	T-2.2 Unrolled models	T-3.1 Validation	T-3.2 What if?	Open Source Code
Risk	(★)	(★★)	(★★★)	(★★)	(★★)	(★)	(★★★)	(★)
Thomas Moreau								
PhD#1								
PhD#2								
PhD#3								
PhD#4								
Postdoc#1								
Postdoc#2								
Engineer#1								

Application domains



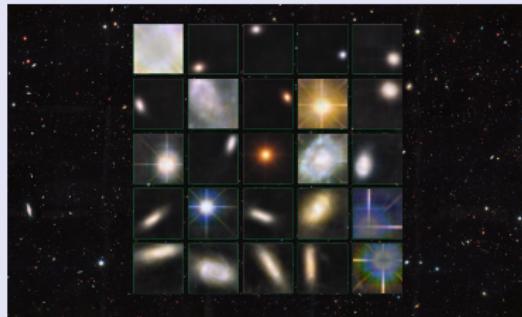
Neuroscience (MEG)

[Dupré*, M.* et al. NeurIPS 2018]



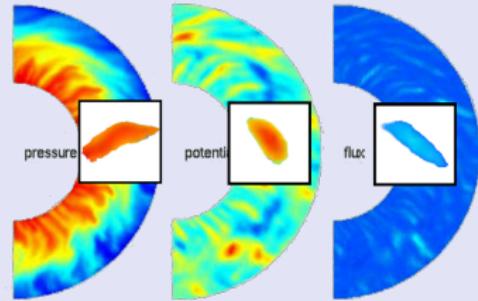
General Anesthesia

[Collaboration with Paris Hospitals]



Astronomy

[M. & Gramfort, PAMI 2020]

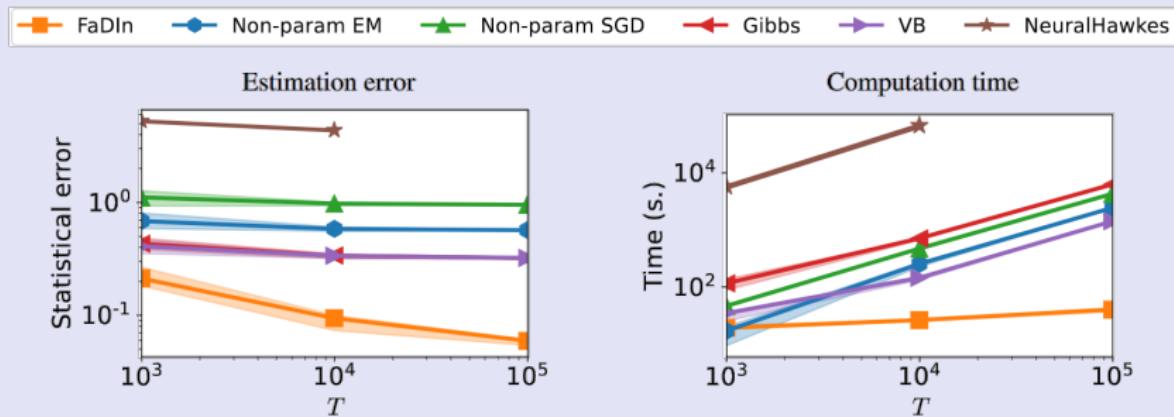


Physics Simulation

[Collaboration with NumPEX Project]

FaDIn – PP framework for novel parametric models

- ▶ Opens the way for general parametric PP models
- ▶ Based on discretization and finite support kernel.
- ▶ Efficient inference thanks to pre-computations,
- ▶ Low statistical error,



[Staerman, Allain, Gramfort & M. ICML 2023]