Reoccurring spatio-temporal spike patterns in parallel spike trains

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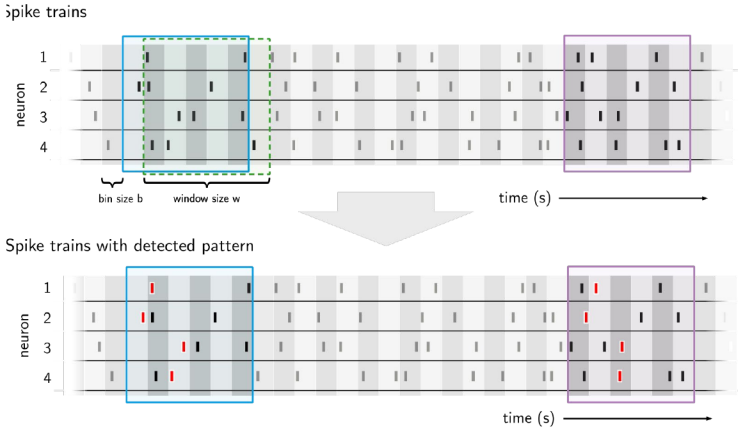
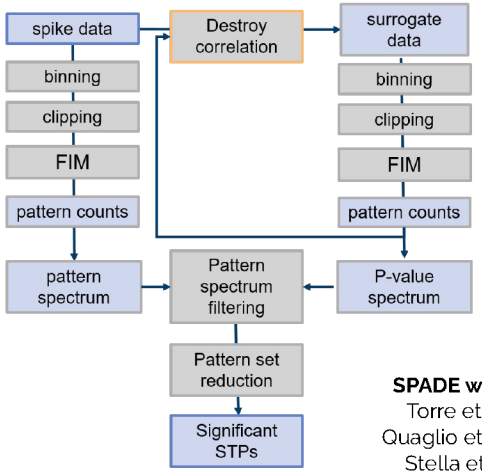
SPADE



STP detection on parallel spike trains with SPADE. Adapted from Stella et al. 2019



SPADE workflow.
Torre et al. 2013,
Quaglio et al. 2017,
Stella et al. 2019

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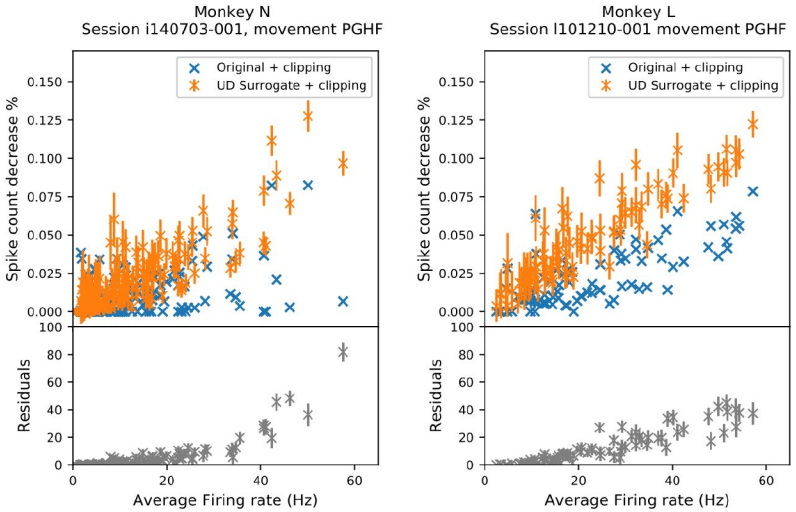
Spike count decrease due to Uniform Dithering

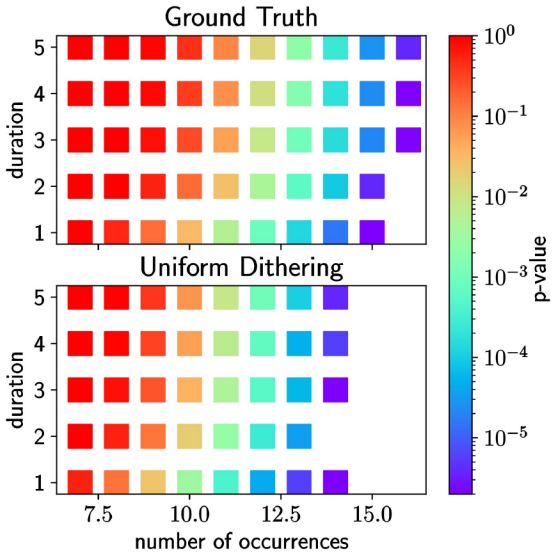


Spike count decrease resulting from UD surrogate generation and clipping. Stella et al. 2020 (in preparation)

Issues of UD:

- does not maintain the dead time of the neuron
- destroys potentially existing ISI regularity
- leads to **spike count decrease after discretization** (clipping) of the spike train, especially for high firing rates.

Problem: overestimation of significance



Shift in the p-value distribution between the original data set and the UD surrogates. The null hypothesis overestimates the significance of the patterns detected in the original data, leading to false positives detection.

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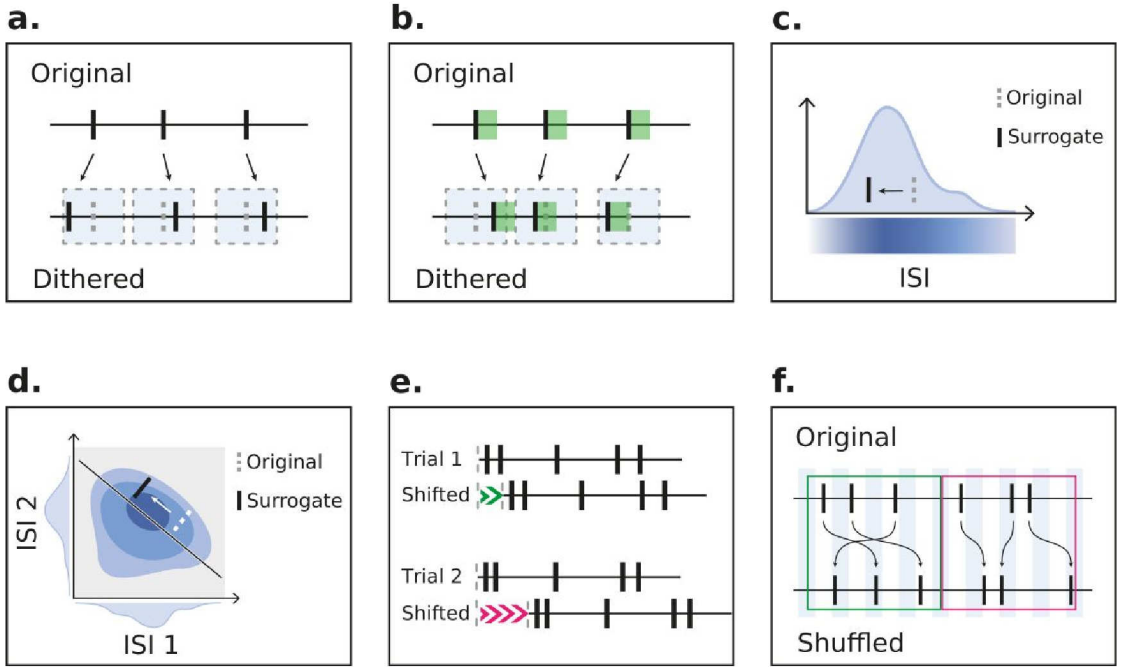
Alternative surrogate techniques



a) Uniform Dithering (UD) (Date et al. 1998; Grün, Rotter (2010)); **b)** Uniform dithering with Dead Time (UD-DT); **c)** ISI-Dithering (ISI-D); **d)** Joint ISI-Dithering (JISI-D) (Gerstein 2004); **e)** Trial Shifting (TR-Shift) (Pipa et al. 2008; Louis et al. 2010a Grün, Rotter (2010)); **f)** Bin Shuffling (Bin-Shuff);

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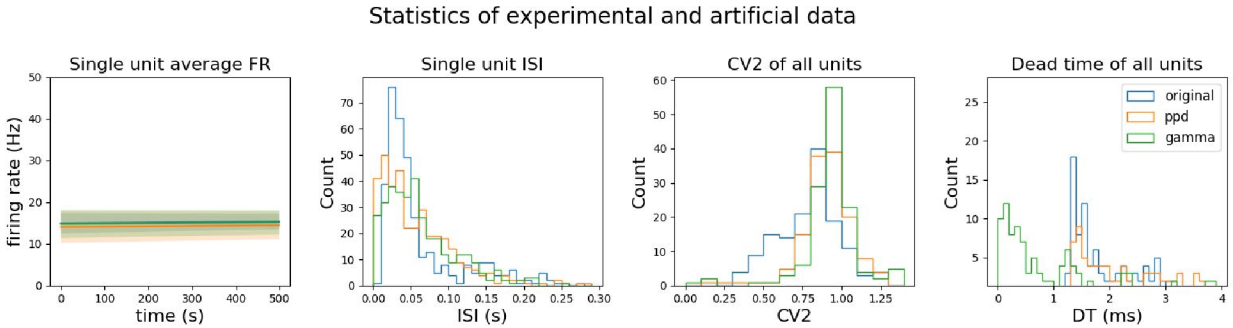
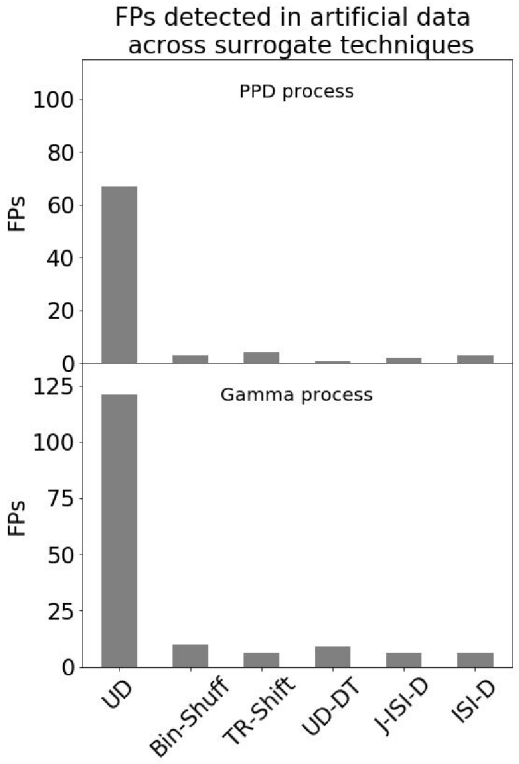
Application of surrogate techniques on artificial data

Artificial data modeled on two sessions of experimental data (Brochier et al. 2018) by Poisson process with dead time (PPD; Deger et al. 2012) and Gamma process.





In artificial data:

- In case of non-Poisson data, **UD leads to a strong reduction in spike count** after clipping, causing a large number of false positives (FPs)
- The other methods show a small number of FPs
- More patterns are detected when their intrinsic regularity is included in the artificial data (Gamma process). Fewer FPs for PPD process
- UD-DT shows a higher number of FPs in the case of Gamma process (for neurons with high firing rate).

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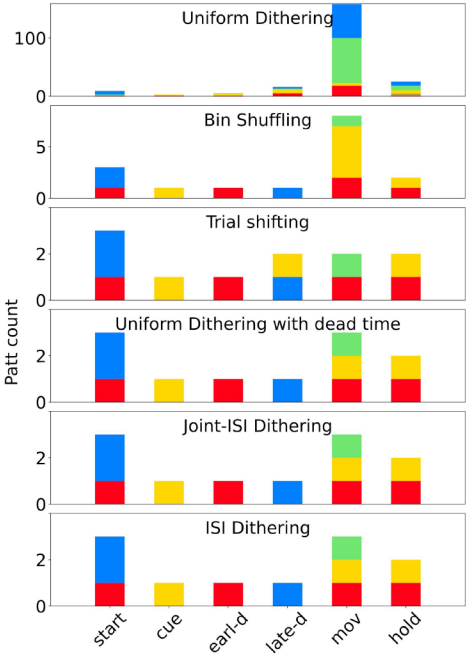
Application of surrogate techniques on experimental data

In experimental data:

- We detect most patterns by using UD (likely to be FPs)
- Higher amount of patterns in start and movement period of the trials for all surrogate techniques (besides UD)
- Same patterns detected across TR-Shift, UD-DT, J-ISI-D, ISI-D. Pattern sizes (number of spikes) ranging from 2 to 5. Pattern occurrences ranging from 11 to 386 (depending on size).



Conclusions

We analyze **experimental data** and **ad-hoc artificially generated independent data** with **six different surrogate techniques**, in order to evaluate their statistical performances when looking for **spatio-temporal spike patterns**. We find:

- all surrogate techniques despite UD keep the spike counts at least approximately identical to the original data after clipping
- firing rate reduction after clipping of the surrogate spike train is the primary reason for FPs
- weakening the ISI/J-ISI property of the original spike train is of lower impact on FPs
- low number of FPs across surrogate techniques besides UD
- we detect the same patterns in experimental data across different surrogate techniques, evidencing the robustness of our findings.

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