Jacques Bourg

Oveview

- Short CV
- Signal and image processing
- Machine learning and deep learning
- Mathematical modelling
- Software development
- Experimental experience
- Other

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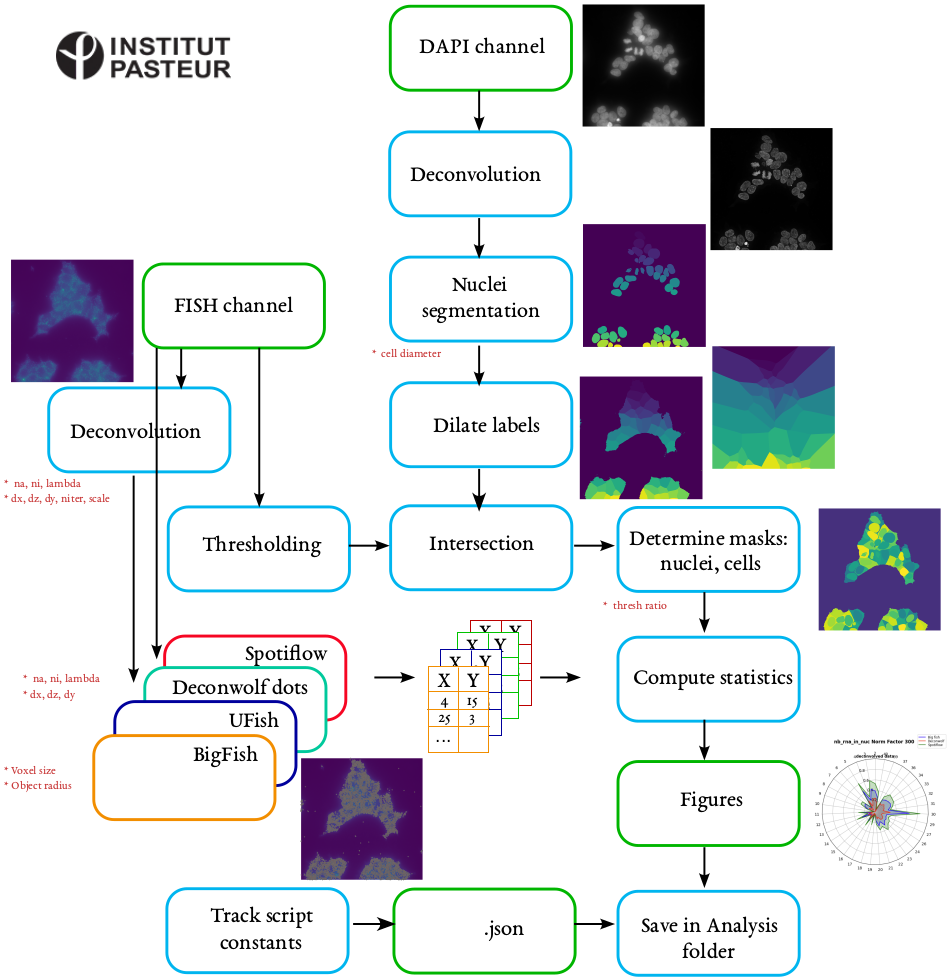
Université Paris Cité

Depixus

INSTITUT PASTEUR

Signal and image processing 1/5

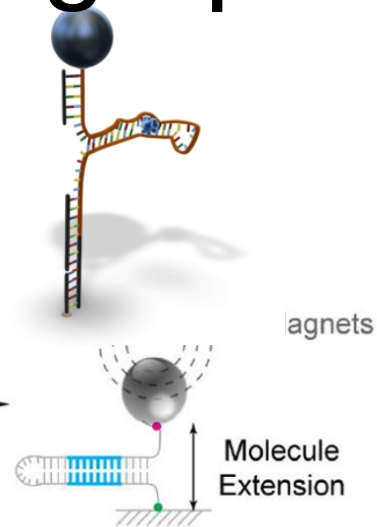


Pipeline to segment and benchmark different state of the art FISH spot detection.

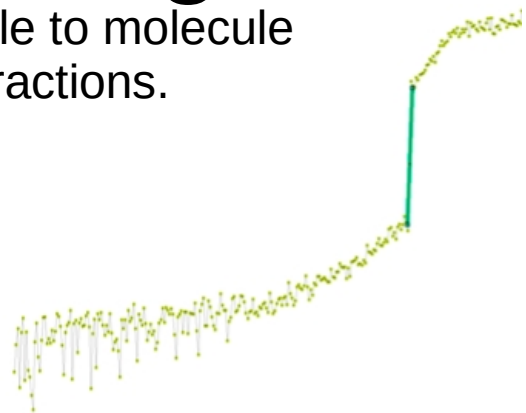
Cross environment function calls (bash).
Deep learning state of the art frameworks :
Cellpose (segmentation), Ufish, Spotiflow...

Signal and image processing 2/5

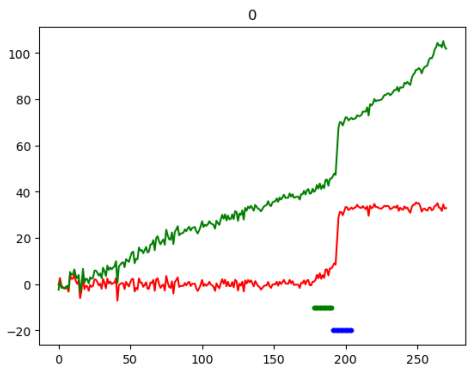
Depixus



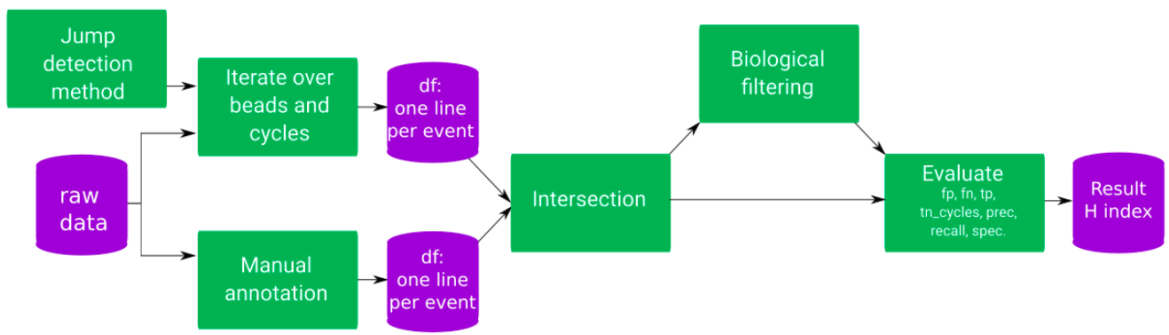
Molecule to molecule interactions.



Drift removal algorithm



Pipeline to benchmark different state of the art change point detection

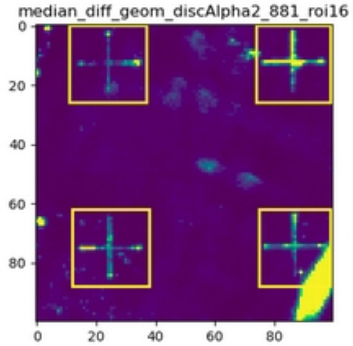


« Ruptures » Truong, Oudre, Vayatis, Selective review of offline change point detection methods, Signal Processing, Volume 167, 2020.

Signal and image processing 3/5

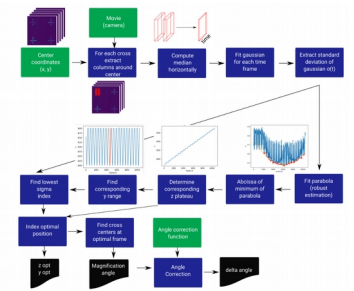
Cross detection algorithm :

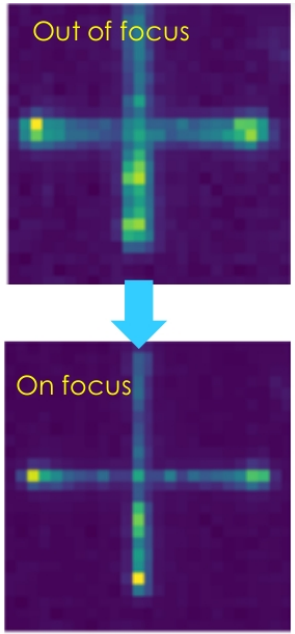
* Cartridge insertion QC.
* Focus Analysis

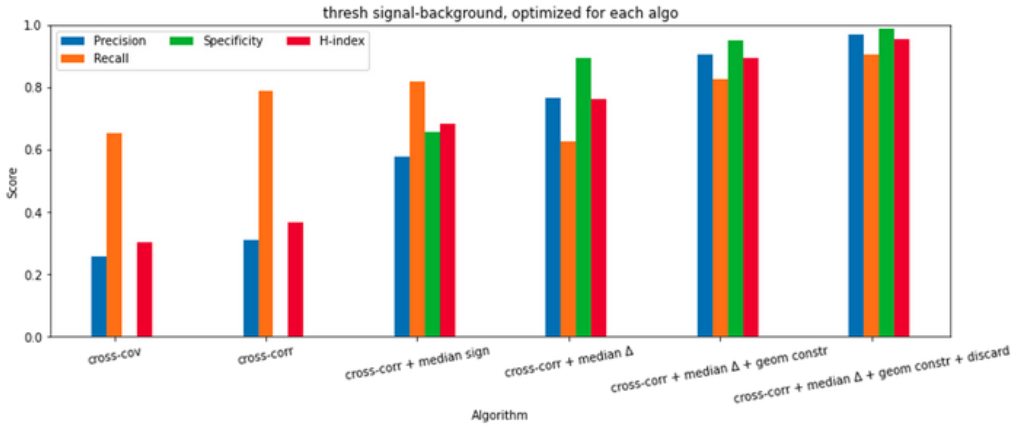


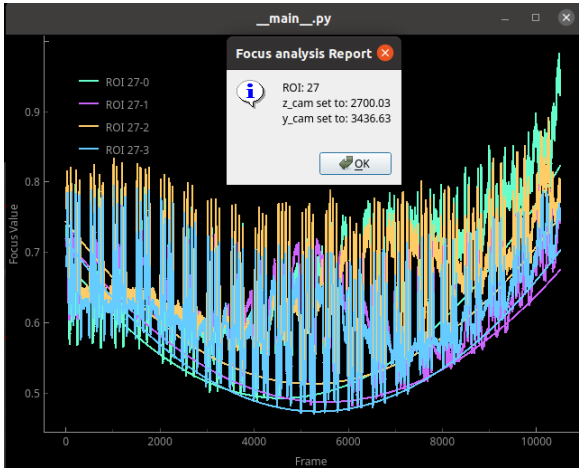
Algorithm design.
Data base benchmarking.
Performance assesing.

Focus procedure



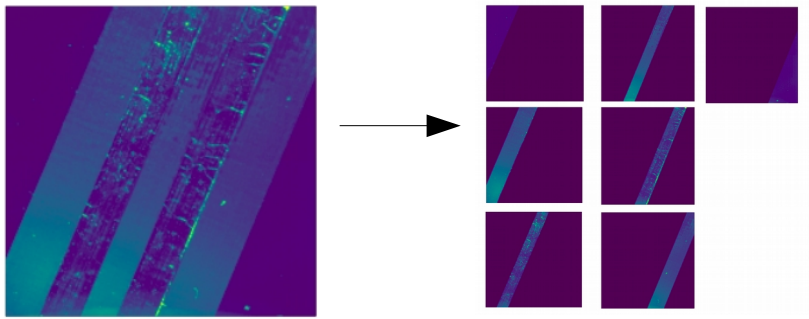






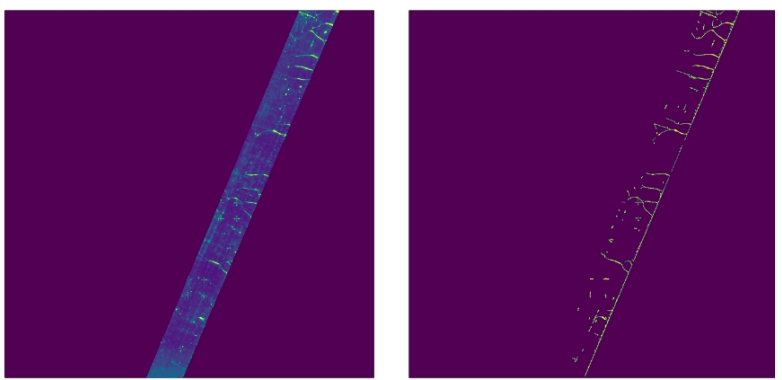
Signal and image processing 4/5

Canal detection



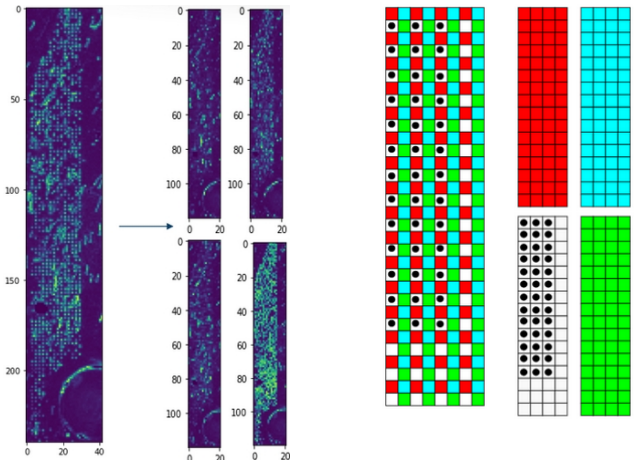
Cross correlations, sobel edge detector, Hough transform, Registration using convolution.

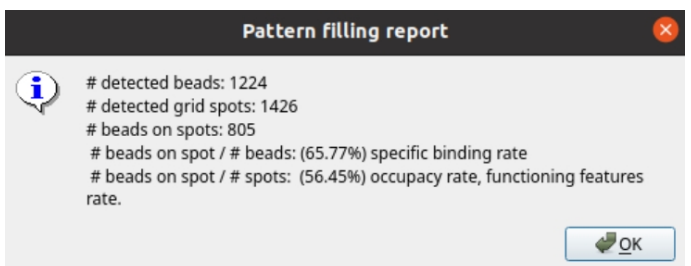
Bubble segmentation on fluidic canal

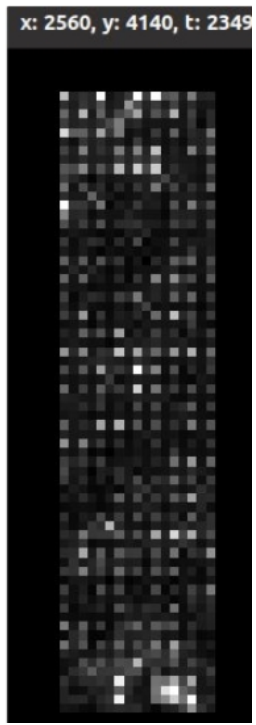


Cross correlations, sobel edge detector, Hough transform, Registration using convolution.

Grid detection : cartridge alignment protocol and surface chemistry quantification

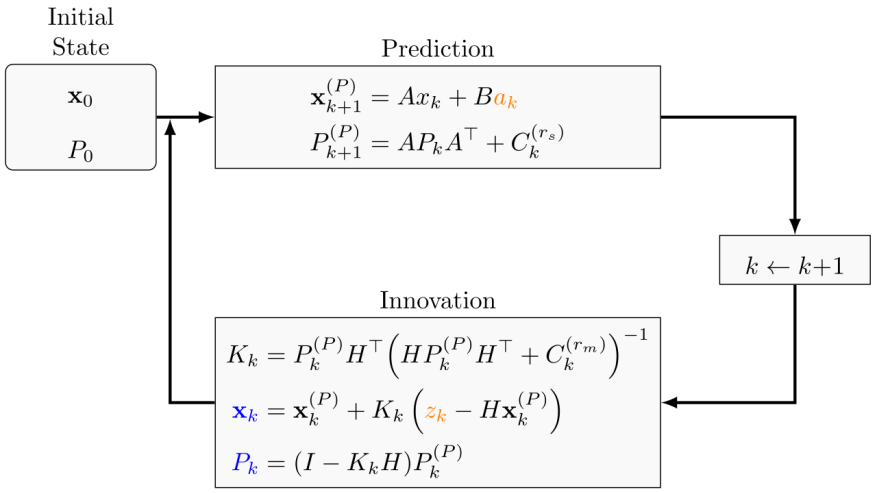




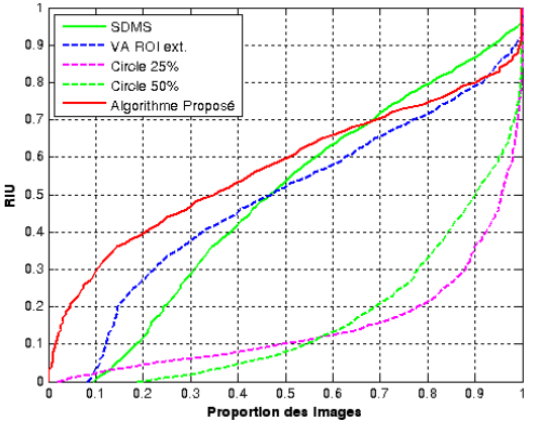


Signal and image processing 5 /5

Kalman filtering for early detection of explosive compounds

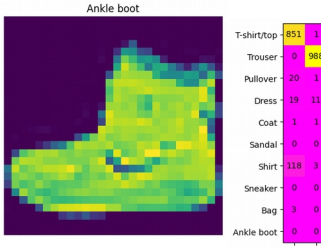


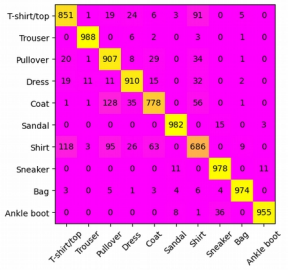
Bottom up segmentation using salient points and Mean-shift



Machine and deep learning 1/2

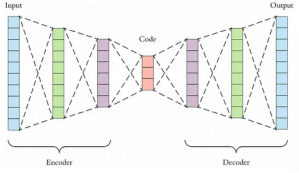
* **Several MOOCs**

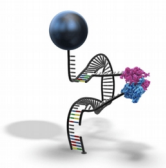


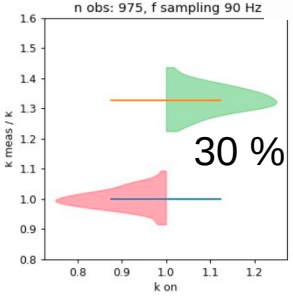


* **Techniques** : Linear regression, Logistic regression, PCA, K-means, KNN, SVM, Random Forests, Deep networks, CNNs.

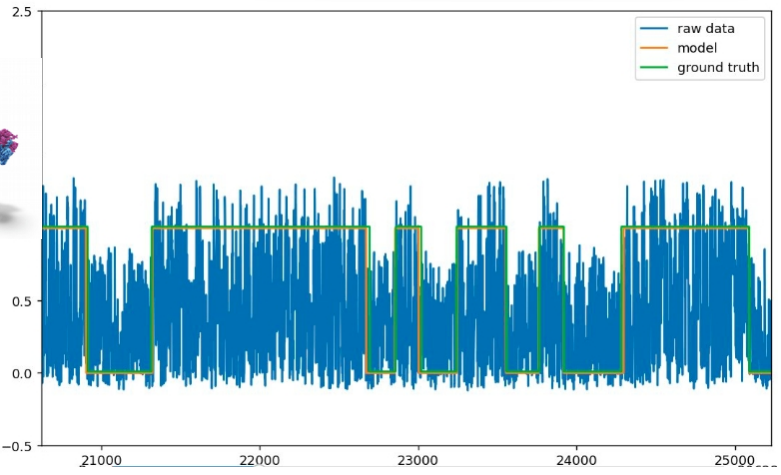
* **Autoencoder** :

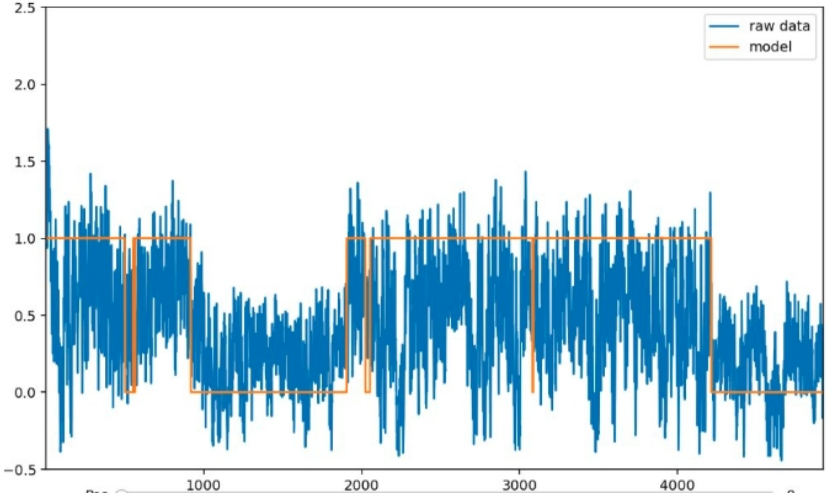






30 % error





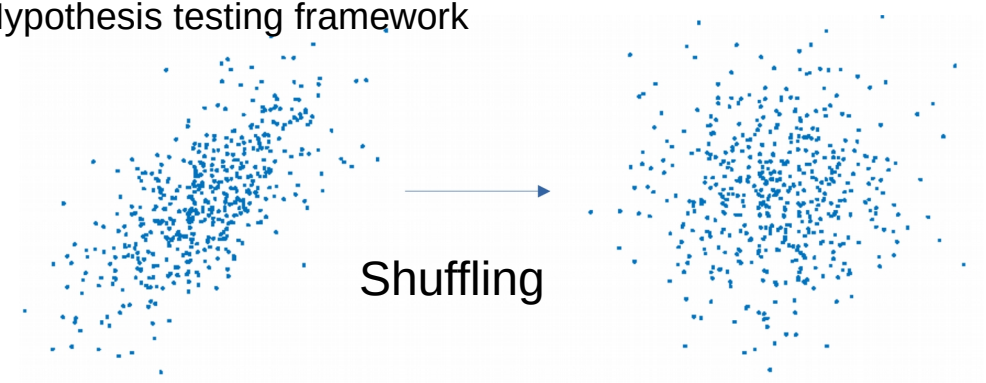
PyTorch

Machine and deep learning 2/2

Statistical significance of PCs

To what extent the observed data is not pure noise ?

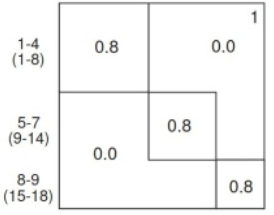
Hypothesis testing framework



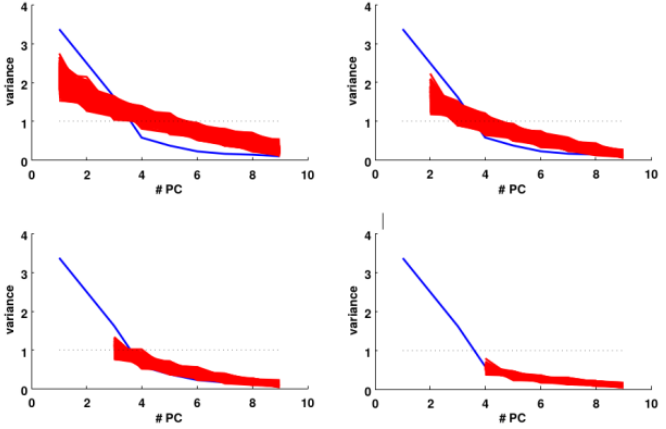
Shuffling provoques a transfer of variance from the signal to the noise.

Solution :
Iteratively remove PC (signal) and shuffle.

Synthetically generated data : correlation matrix



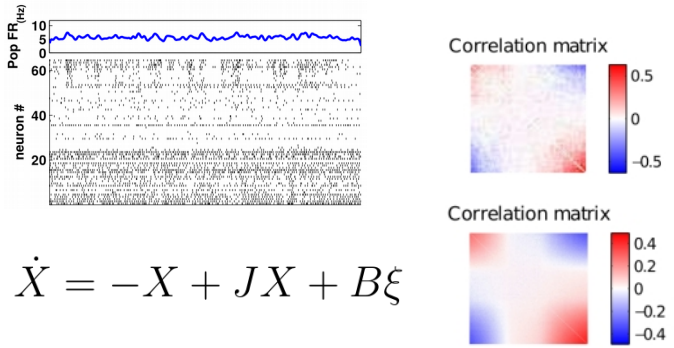
3 iterations to converge



Mathematical modelling 1 / 2

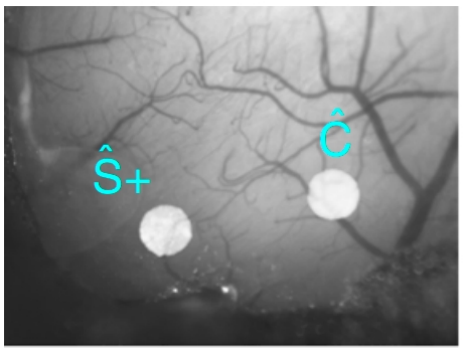
* Network dynamics
  (dyamical systems theory)

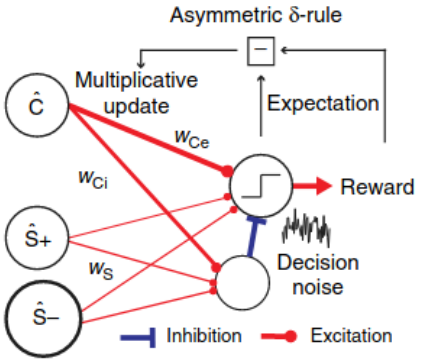
Data



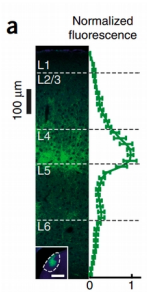
Model $\dot{X} = -X + JX + B\xi$

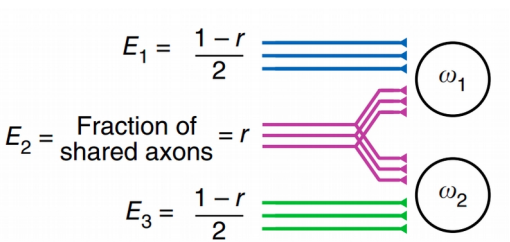
* Behavioral model of decision making



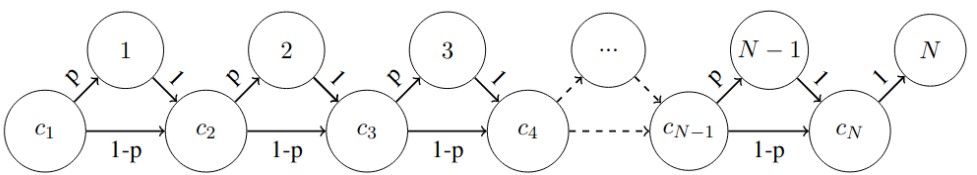


* Model of synaptic variability





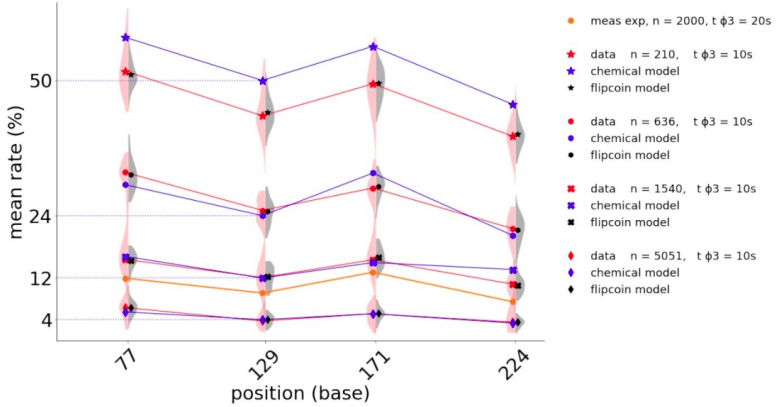
* Combinatorial identities



$$\sum_{k=m+1}^{N-1} \binom{k-1}{m} p^{m+1}(1-p)^{k-1-m} + \sum_{w=0}^{m} \binom{N-1}{w} p^{w}(1-p)^{N-1-w} = 1$$

Mathematical modelling 2 / 2

* Chemical modelling of the antibody-hairpin reaction :



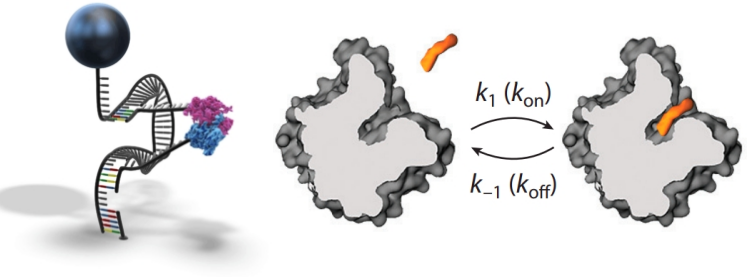
$$S + AB \underset{k_{off}}{\overset{k_{on}}{\rightleftharpoons}} S.AB$$

$$p_{(t)} = p_{max}(1 - e^{-\frac{t}{\tau}})$$

$$p_{max} = \frac{\frac{[AB]}{K_{off}}}{1 + \frac{[AB]}{K_{off}}}$$

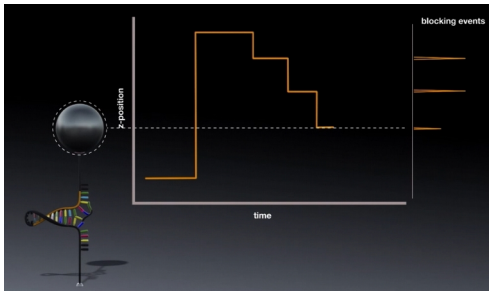
$$\tau = \frac{1}{k_{off}(1 + \frac{[AB]}{K_{off}})}$$

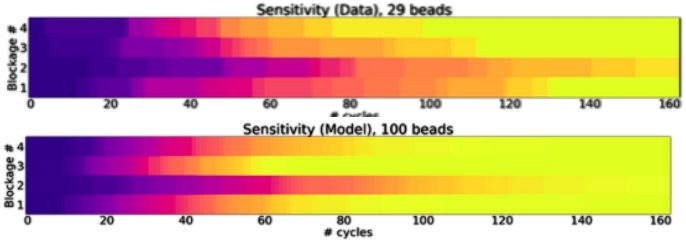
* Experiment design : protein protein interaction

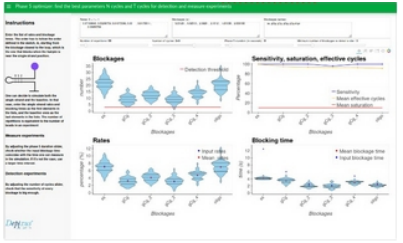


$$\bar{k}_n \in [\frac{k}{1 + \frac{3}{\sqrt{n}}}, \frac{k}{1 - \frac{3}{\sqrt{n}}}]$$

* Probabilistic modelling of a hairping closing during a force cycle







Software development

Core contributor for data analysis software :

- Mark alignment detection (cartridge well inserted).
- Determine optimal focus protocol (z).
- Grid detection for fine alignment of pixels center with beads and fluidics protocol dev.

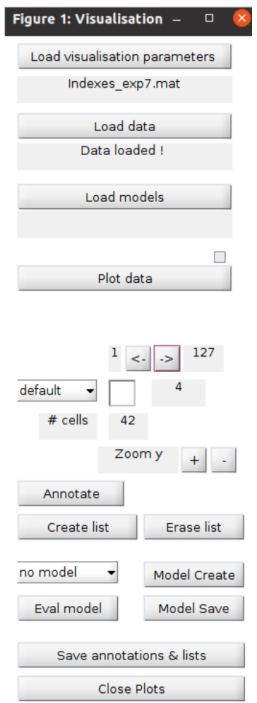
Library for data analysis

magna_module.aggregate_values_over_list_of_data_frames(*list_pkl_files_or_df, column_to_aggregate*) [source]

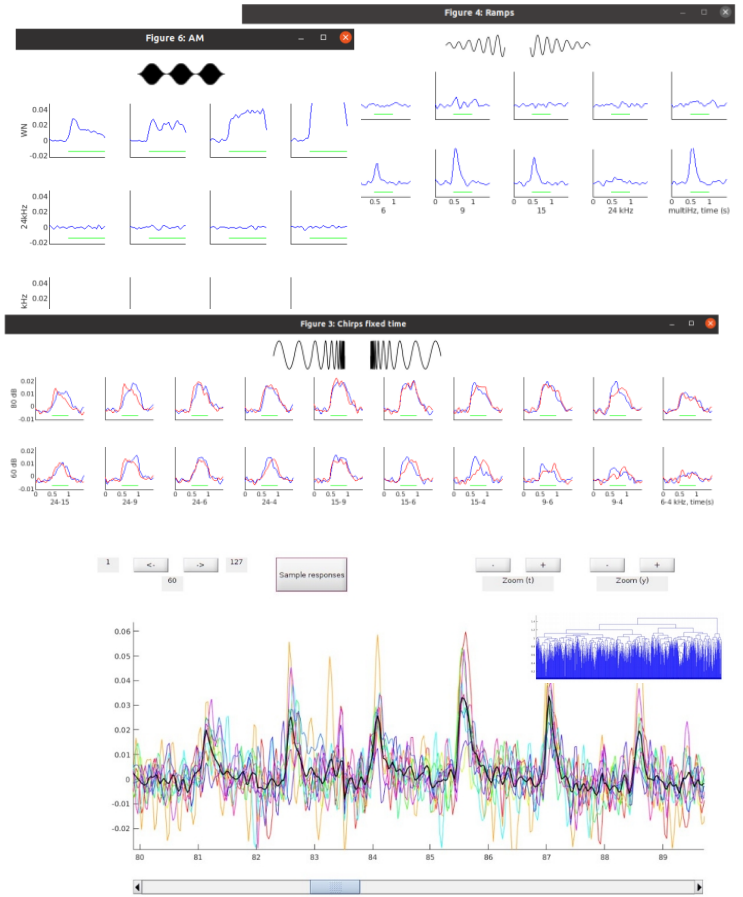
Given a list of either:

.pkl file names ['./file2/first.pkl','./file2/fsecond.pkl']
dataframes [df1,df2,...]

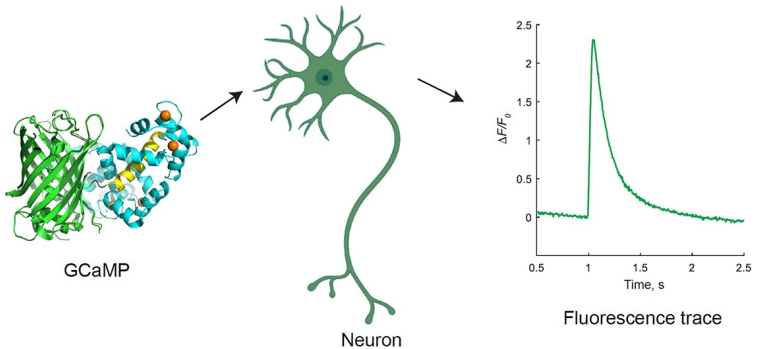
Goes over the refered dataframes, picking all the values in a selected column, and gives back a list with all the values aggregated

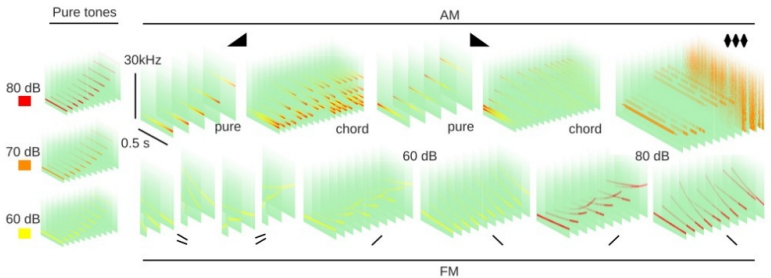


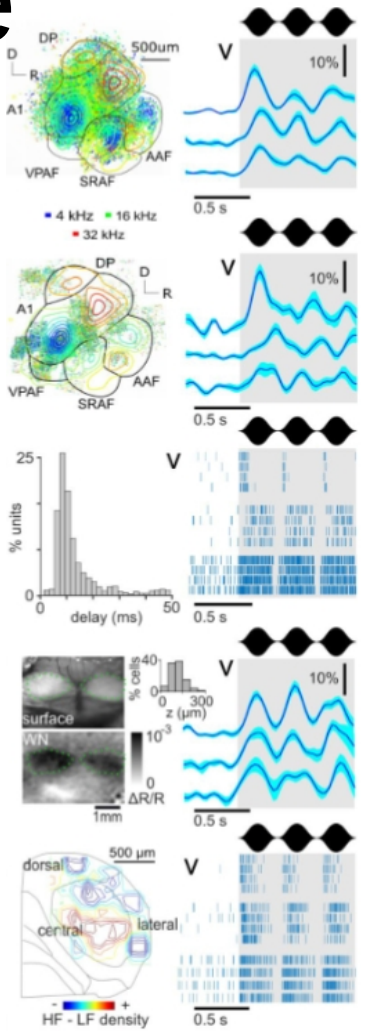
2P cell analysis, several stimuli

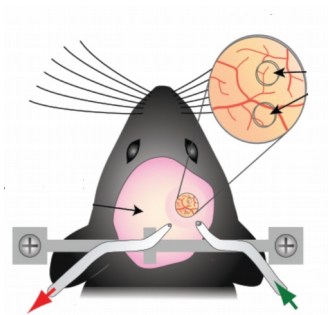


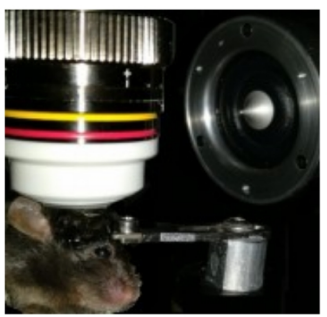
Experimental experience



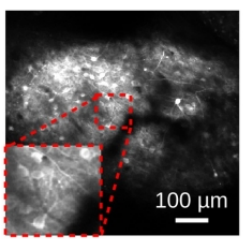




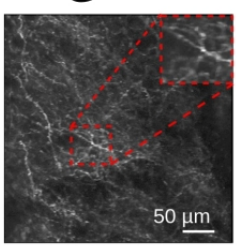




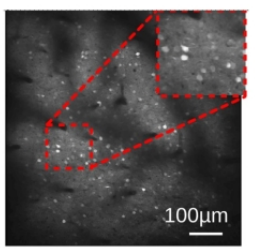
Inferior colliculus



MGB axons @ A1



Auditory cortex



Other

- Teaching : neuron biophysics and sensory coding and perception (Paris Diderot and Orsay : 8 h/year). Pasteur : spot detection for rna imaging (3h), pasteur neubias course.
- Conference presentations : speaker at COSYNE (Salt Lake City, 2015), (GDR neuro, Strasbourg 2017), APAN (Chicago, 2019).
- HR : elaboration of technical tests, interviews and hiring of a senior data scientist.
- Project leader of an integrative project : elaboration of functional blocks of the processes (Ishikawa fishbone diagrams) related to the instrument.

Publications

* A spatial code for temporal cues is necessary for sensory learning. Bagur*, **Bourg*** et al.

* Combinatorial identities using Bernoulli graphs. **Bourg**

* Multilaminar networks of cortical neurons integrate common inputs from sensory thalamus. Morgenstern, **Bourg**, and Petreanu.

* Cortical recruitment determines learning dynamics and strategy. Ceballo*, **Bourg***, Kempf* et al.

* Targeted Cortical Manipulation of Auditory Perception. Ceballo et al.