

Jacques Bourg

Overview

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



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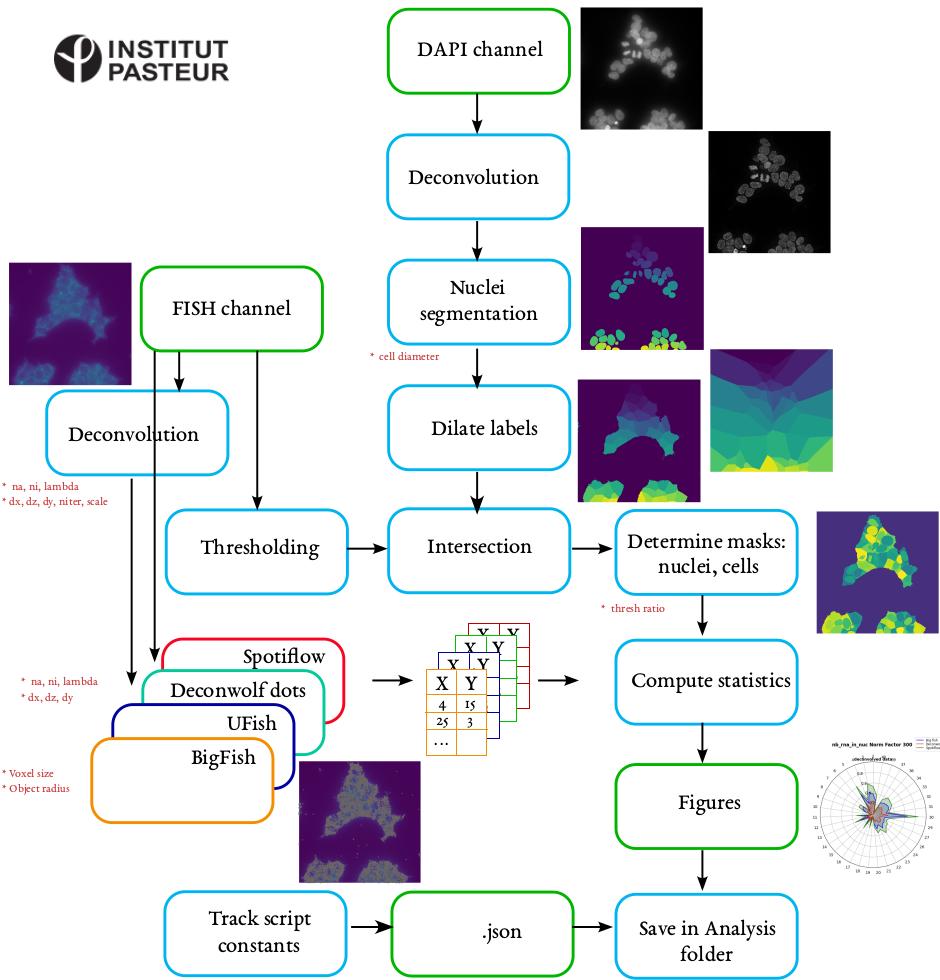
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Paris Cité



Signal and image processing 1/5



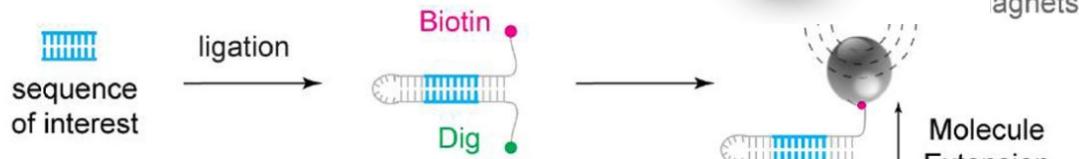
Pipeline to quantify rna expression in cells using Fluorescence imaging

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

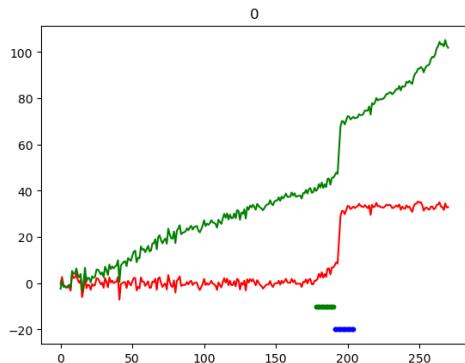
Signal and image processing 2/5



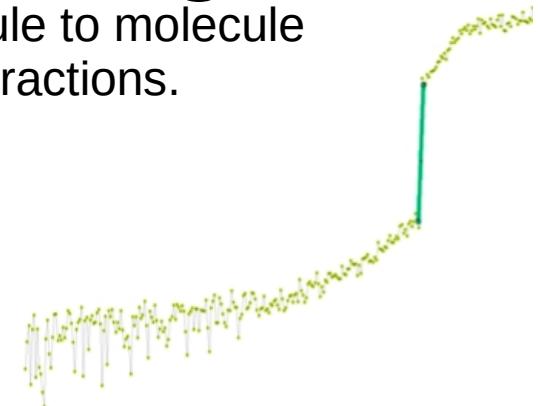
Depixus



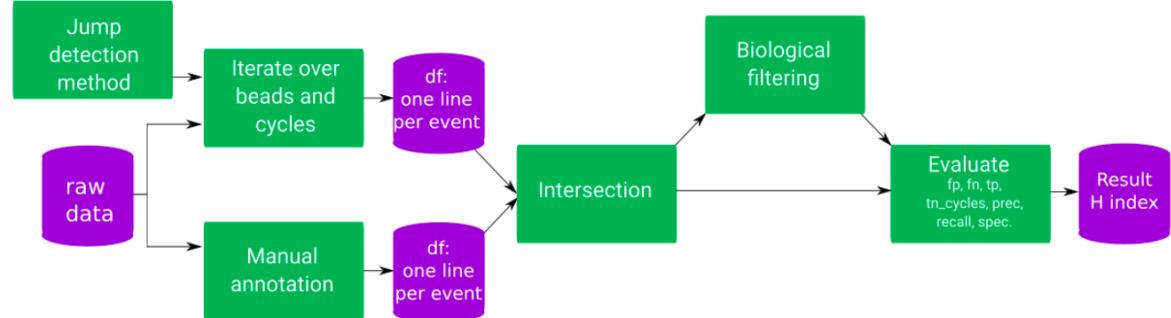
Drift removal algorithm



Molecule to molecule interactions.



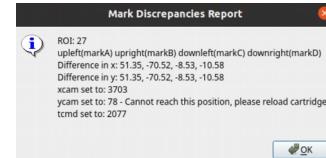
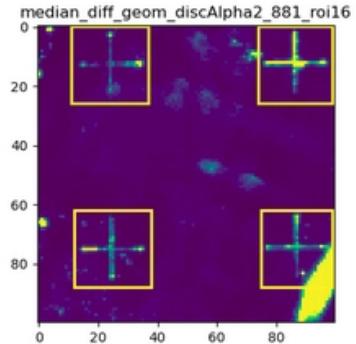
Pipeline to benchmark different state of the art change point detection



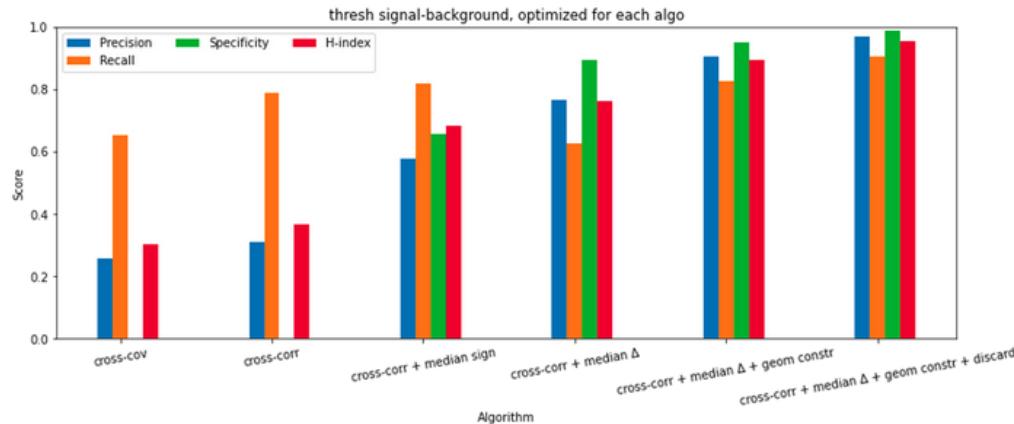
Signal and image processing 3/5

Cross detection algorithm :

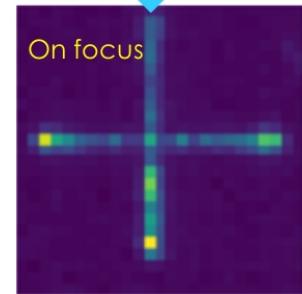
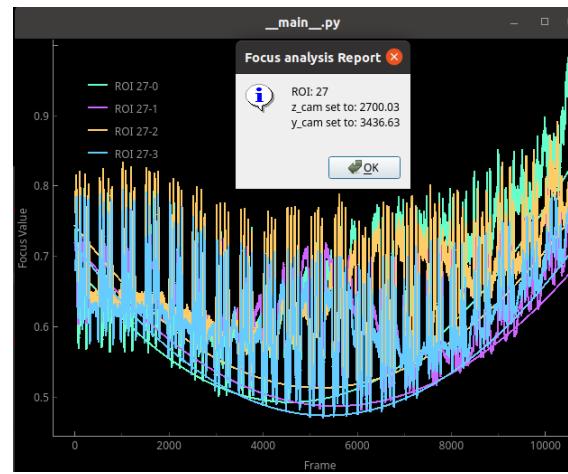
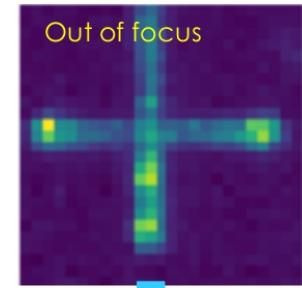
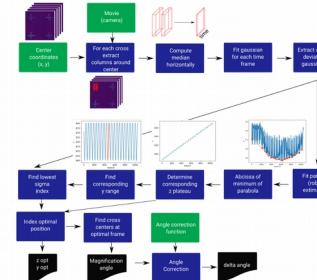
- * Cartridge insertion QC.
- * Focus Analysis



Algorithm design.
Data base benchmarking.
Performance assesing.

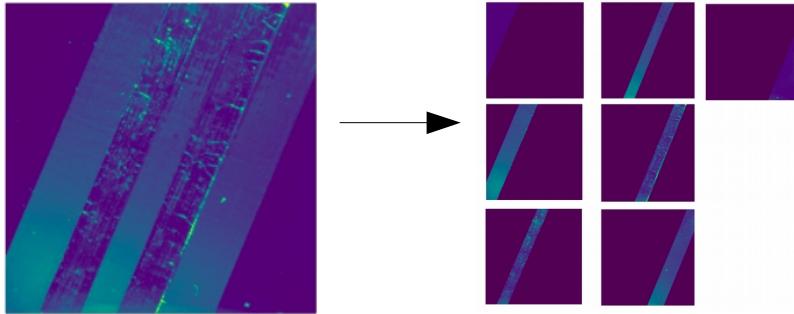


Focus procedure



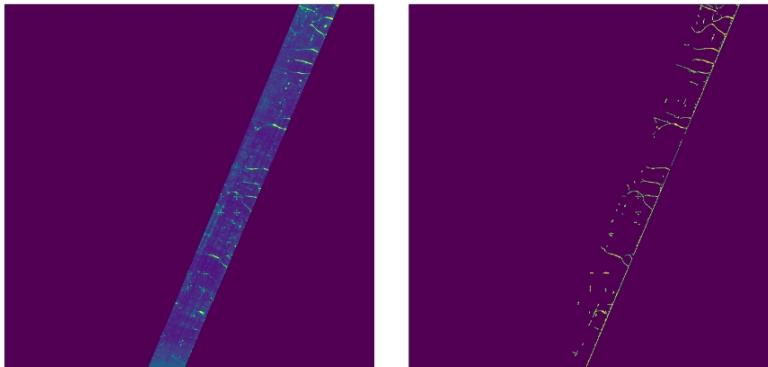
Signal and image processing 4/5

Canal detection



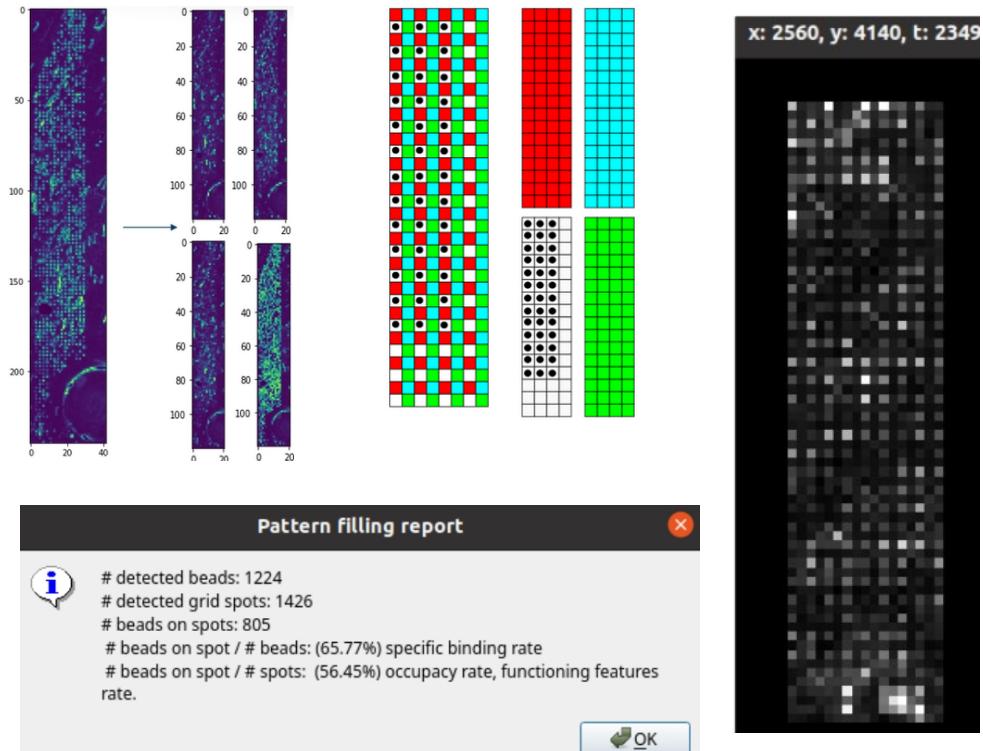
Cross correlations, sobel edge detector, Hough transform, Registration using convolution.

Bubble segmentation on fluidic canal



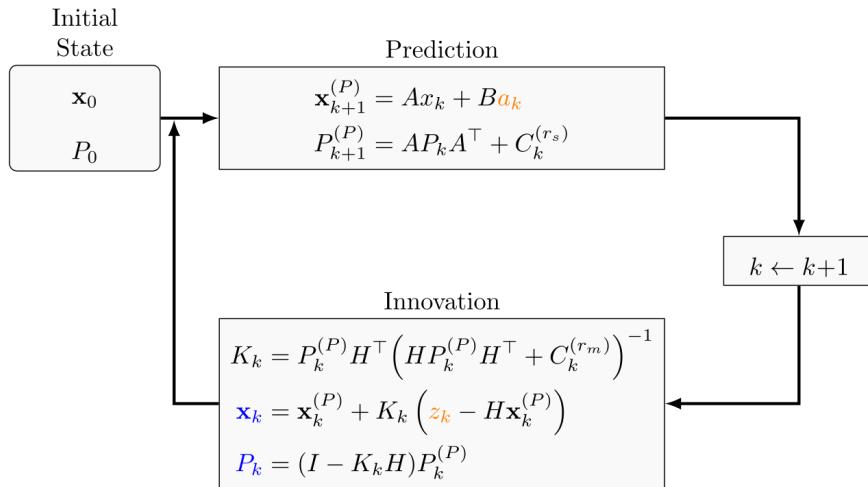
Cross correlations, sobel edge detector, Hough transform, Registration using convolution.

Grid detection : cartridge alignment protocol and surface chemistry quantification

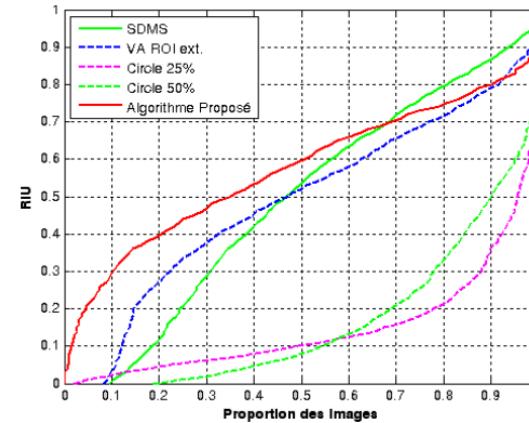


Signal and image processing 5 /5

Kalman filtering for early detection of explosive compounds



Bottom up segmentation using salient points and Mean-shift



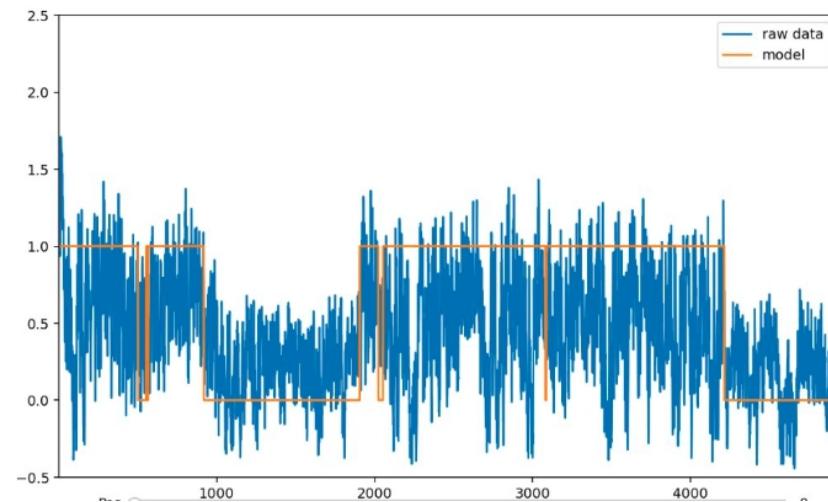
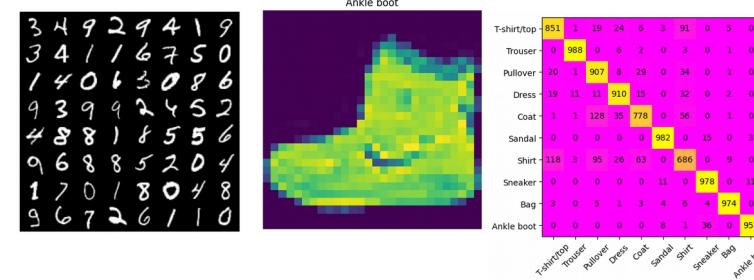
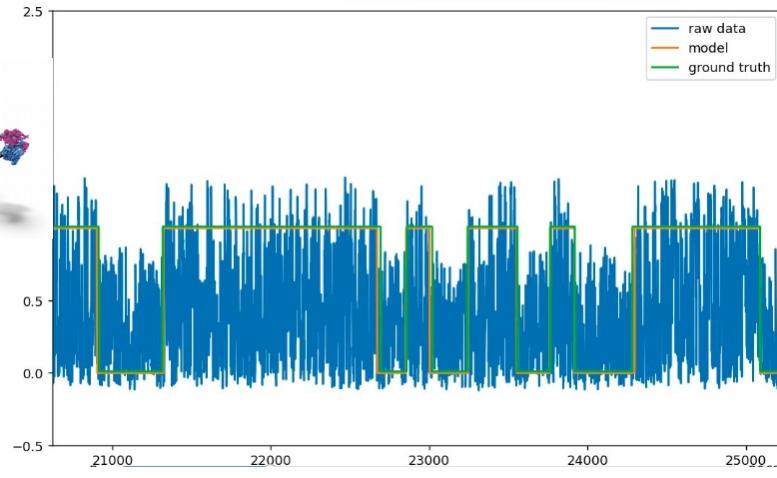
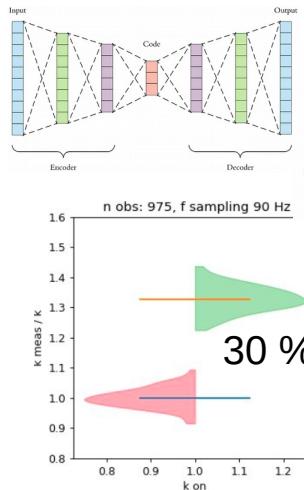
Machine and deep learning 1/2

* Several MOOCs



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

* Autoencoder :

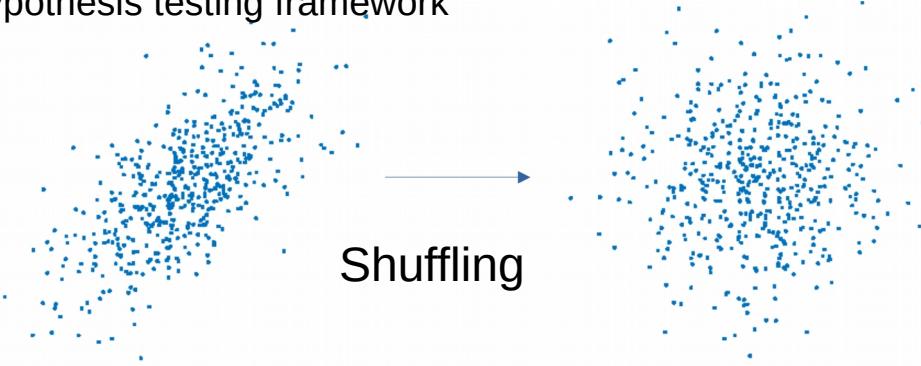


Machine and deep learning 2/2

Statistical significance of PCs

To what extent the observed data is not pure noise ?

Hypothesis testing framework



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

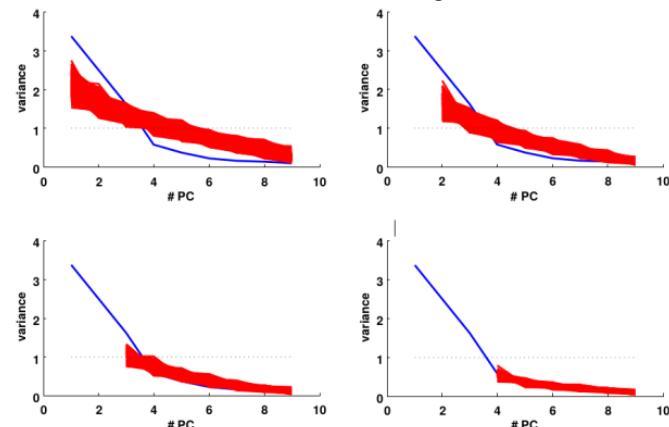
Solution :

Iteratively remove PC (signal) and shuffle.

Synthetically generated data : correlation matrix

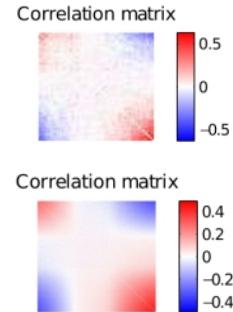
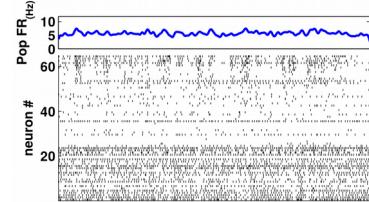
		1
1-4 (1-8)	0.8	0.0
5-7 (9-14)	0.0	0.8
8-9 (15-18)	0.8	0.0

3 iterations to converge



Mathematical modelling 1 / 2

- * Network dynamics
(dynamical systems theory)

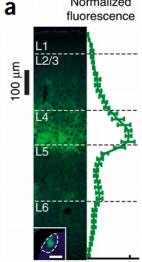


Model

$$\dot{X} = -X + JX + BX \xi$$

- * Model of synaptic variability

a



$$E_1 = \frac{1-r}{2}$$

ω_1

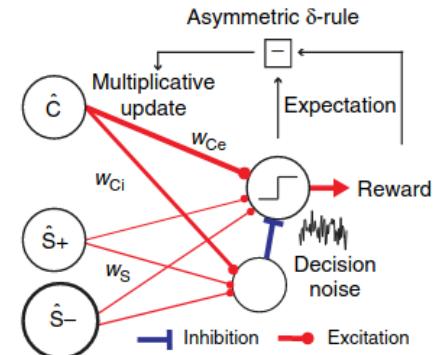
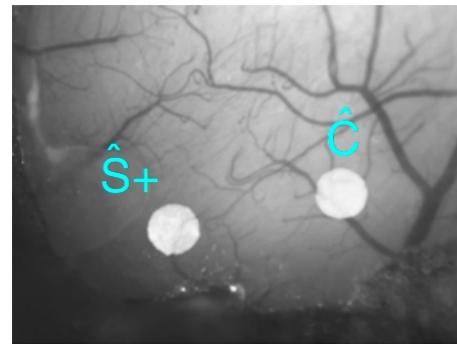
$$E_2 = \text{Fraction of shared axons} = r$$

ω_2

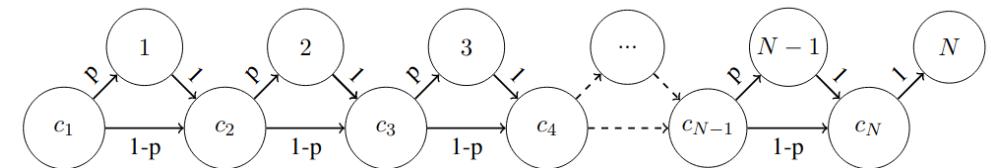
$$E_3 = \frac{1-r}{2}$$

ω_3

- * Behavioral model of decision making



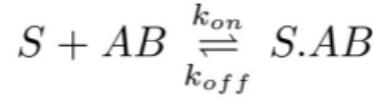
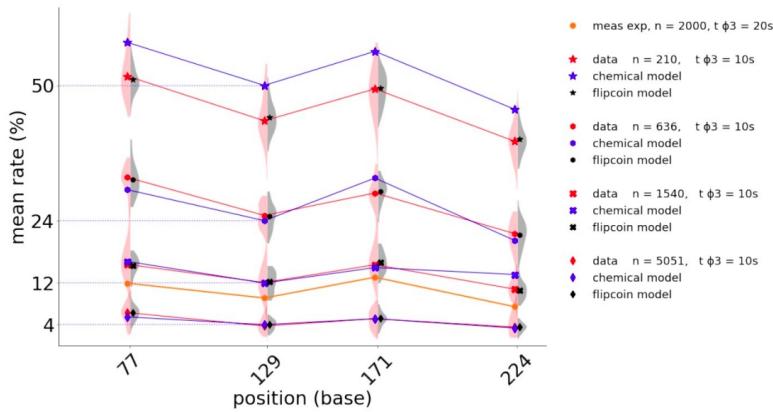
- * Combinatorial identities



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

Mathematical modelling 2 / 2

* Chemical modelling of the antibody-hairpin reaction :

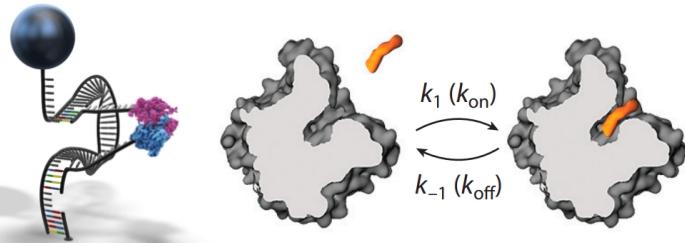


$$p(t) = p_{max}(1 - e^{-\frac{t}{\tau}})$$

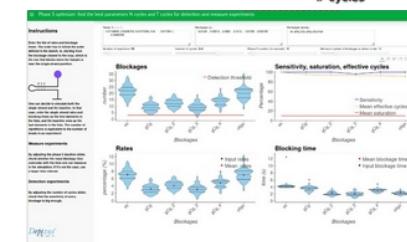
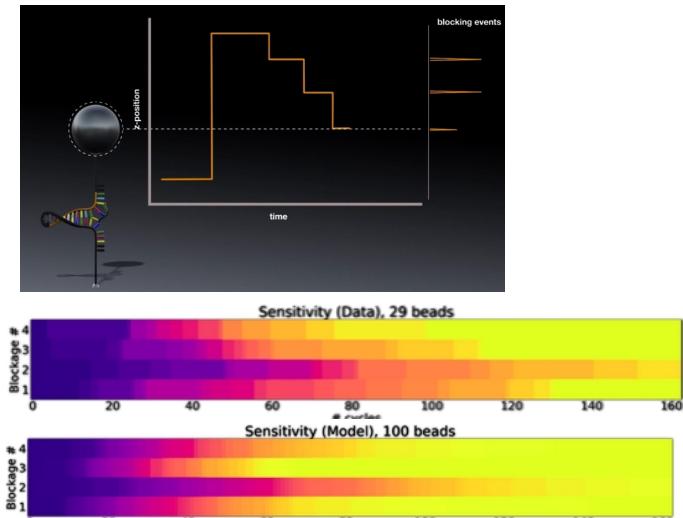
$$p_{max} = \frac{[AB]}{1 + \frac{[AB]}{K_{off}}}$$

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

* Experiment design : protein protein interaction



* 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_pk1_files_or_df,  
column_to_aggregate) [source]
```

Given a list of either:

```
.pk1 file names ['./file2/first.pk1','./file2/fsecond.pk1']  
dataframes [df1,df2,...]
```

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

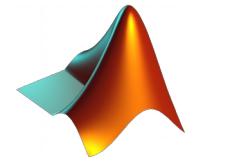


Figure 1: Visualisation

Load visualisation parameters

Indexes_exp1.mat

Load data

Data loaded !

Load models

Plot data

1 <-> 127

default ▾ 4

cells 42

Zoom y + -

Annotate

Create list

Erase list

no model ▾ Model Create

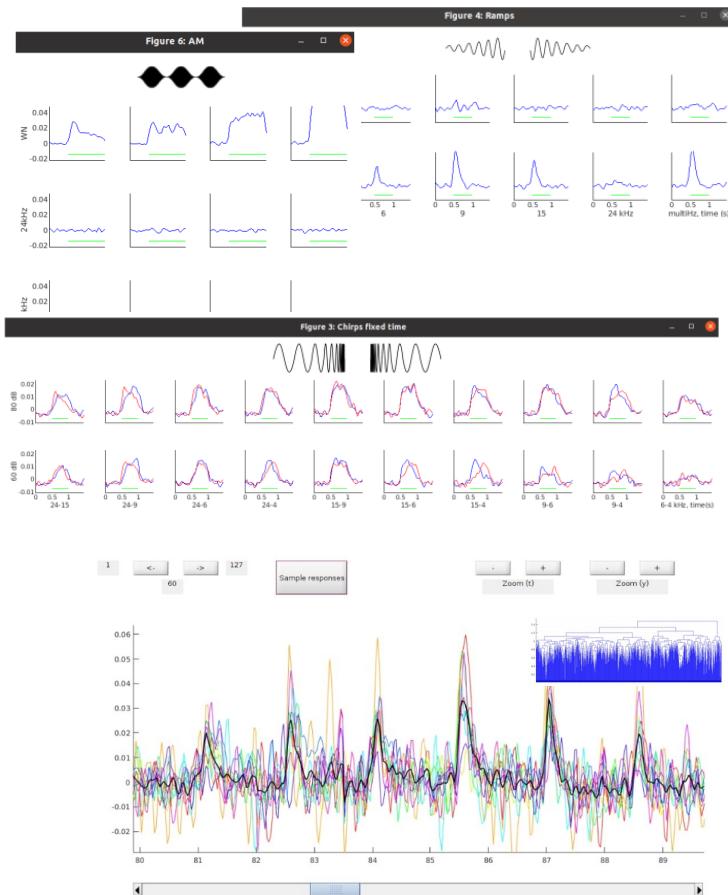
Eval model

Model Save

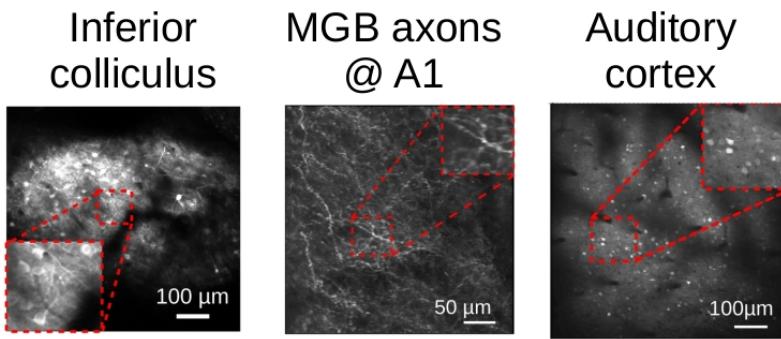
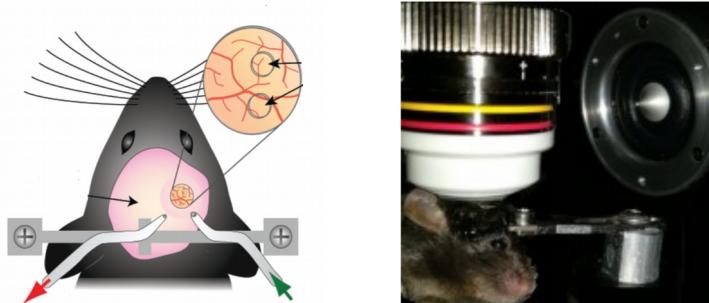
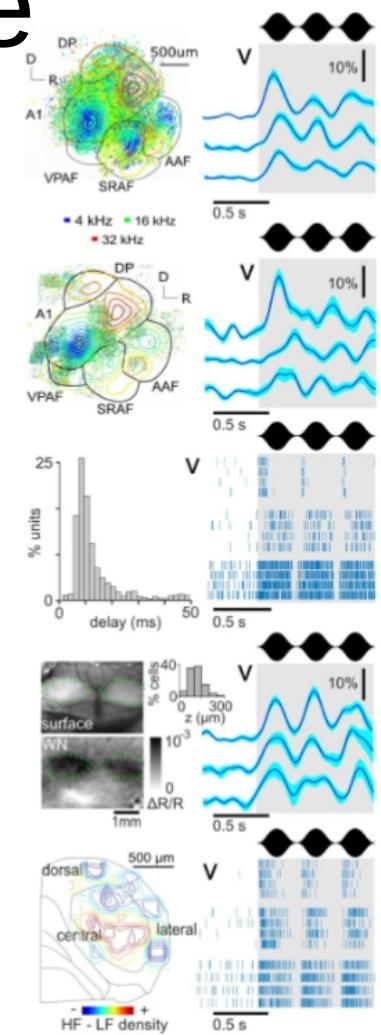
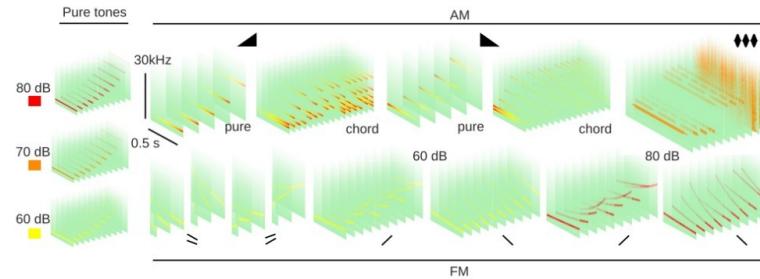
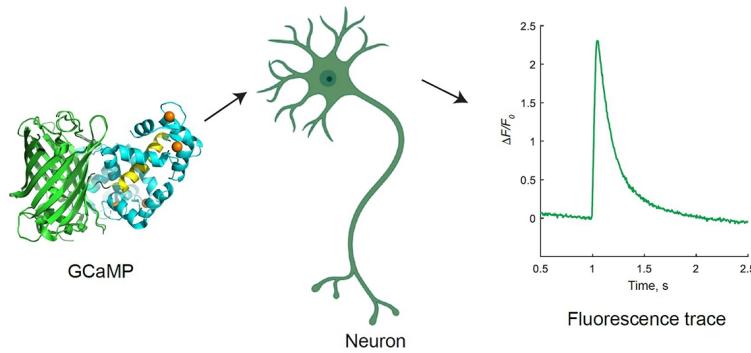
Save annotations & lists

Close Plots

2P cell analysis, several stimuli



Experimental experience



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. **Science Advances**
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.
