cck

Borges. Ficciones de un Tiempo Infinito
Artes Visuales /
Ciclo de Charlas y Conferencias

Borges y la Memoria
(parte I - Funes el Memorioso)

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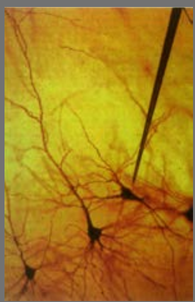
Lic. en Física, Dr. en Matemática Aplicada y Dr. en Neurociencia

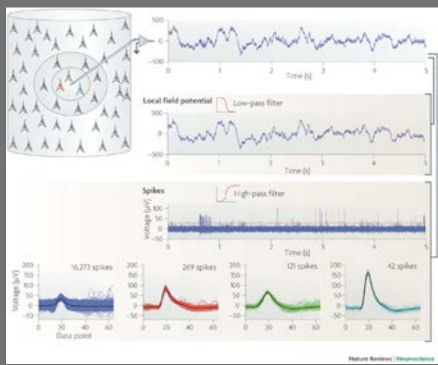
Jueves 4 de agosto, 18.30h - Auditorio 513

Neurociencia de Sistemas

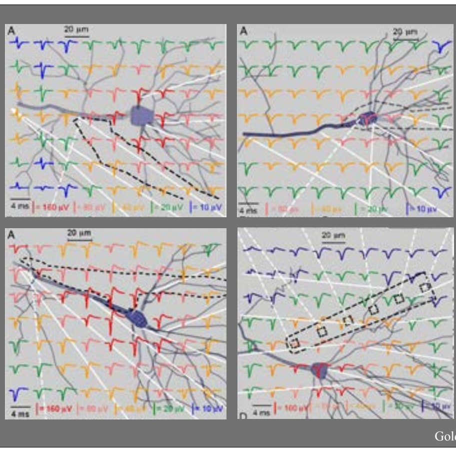
- Clase 1. Introducción
- Clase 2. Registros extracelulares y Spike sorting.
- Clase 3. Procesado de información visual.
- Clase 4. Percepción y memoria.
- Clase 5. Decodificación – Teoría de la información.
- Clase 6. Electroencefalografía – Análisis de tiempo-frecuencia y Wavelets.
- Clase 7. Potenciales evocados – Análisis de ensayo único.
- Clase 8. Dinámica no-lineal – Sincronización.

Extracellular recordings

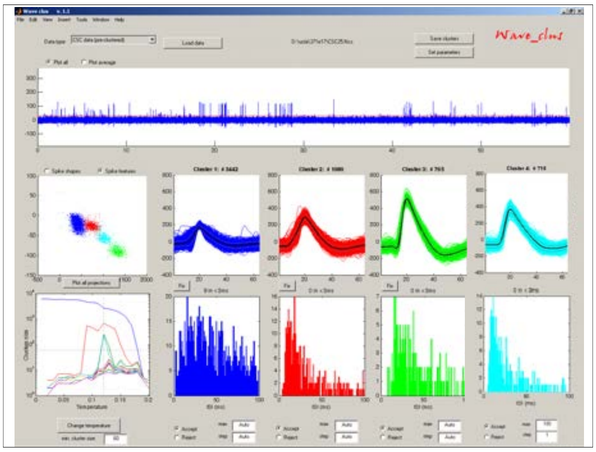




Nature Reviews Neuroscience 10: 173-185; 2009

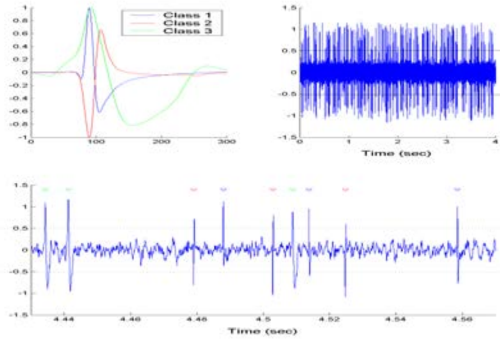


Gold et al 2006



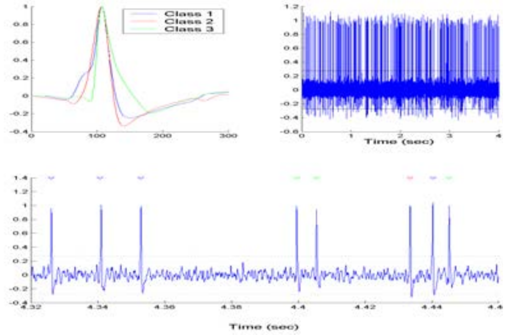
Ex. 1

Simulated data



Ex. 2

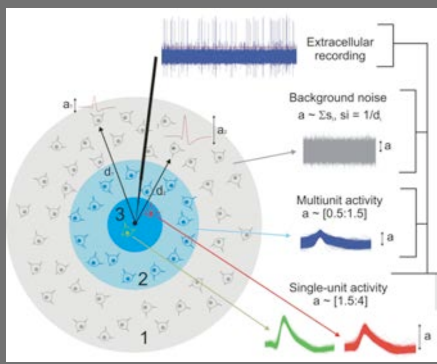
Simulated data



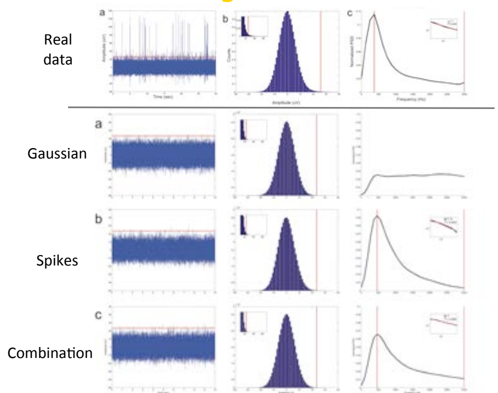
Simulation of extracellular recordings

Juan Martinez Gomez

Martinez et al. J. Neuroscience methods, 2009

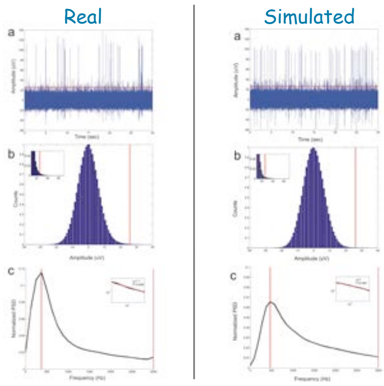


Background noise

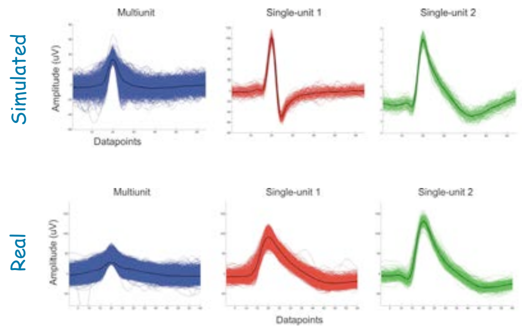


Which one is the real data?

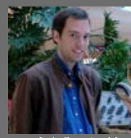
Real | Simulated



Results



A more detailed model...



Luis Camuñas Mesa
Neural Computation, 2013

www.le.ac.uk/csn/neurocube

Generation of extracellular potentials

- Dendritic surface ten to twenty times that of the soma
- Only a small portion of the current flows across the soma
- The neuron branching has an effect on the extracellular potential

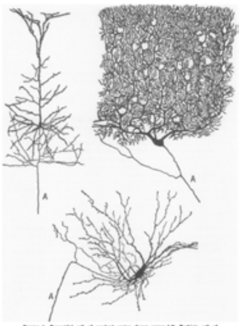
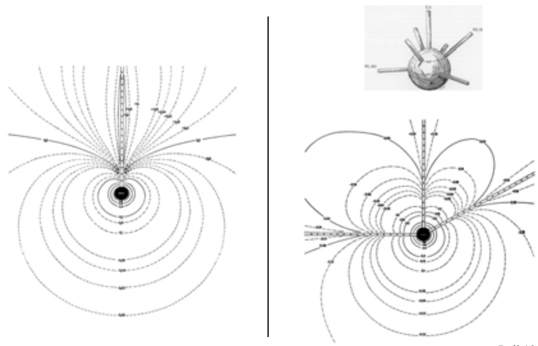


FIGURE 1 Pyramidal cell of cerebral cortex shown upper left. Purkinje cell of cerebellum shown upper right. Motoneuron of spinal cord shown below. In each case, the letter, A, indicates the axon, which is cut off. These illustrations are reproduced with only slight modification from the classic work of Ramón y Cajal (1909).

Rall 1962

Distribution of extracellular potential



Rall 1962

Line source approximation

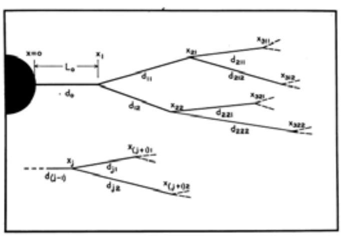
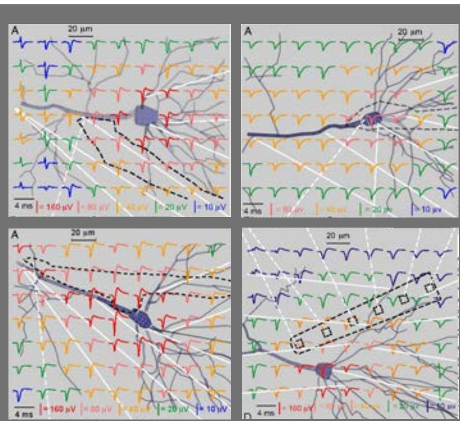
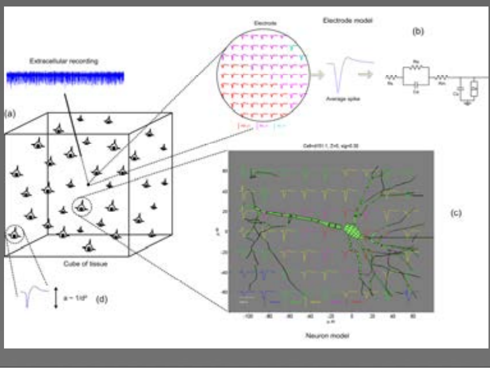


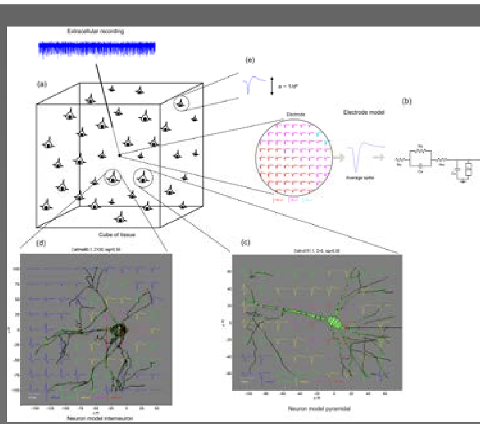
FIGURE 3-A Dendritic branching diagrams to illustrate the subscript notation used in the treatment of arbitrary branching patterns (see, Rall, 1959).

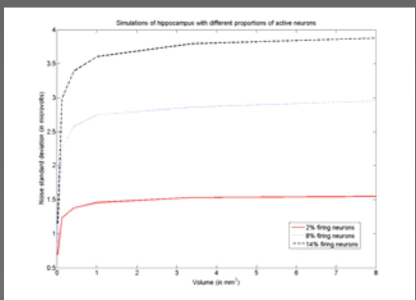


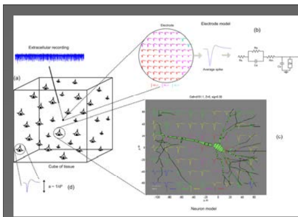
Gold et al 2006

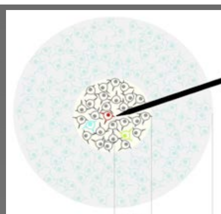
NeuroCube

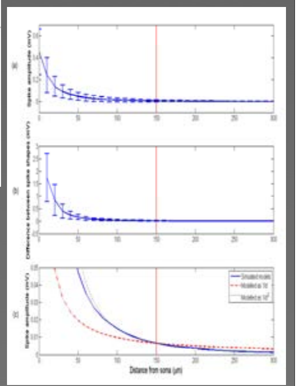


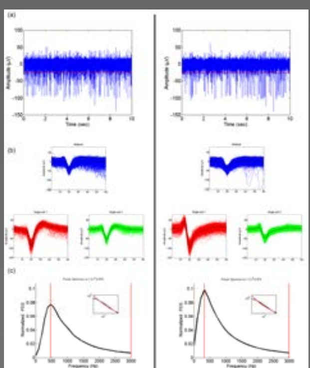




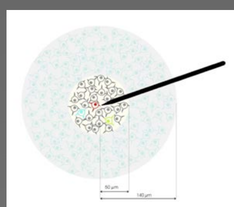


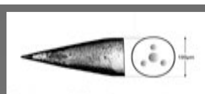






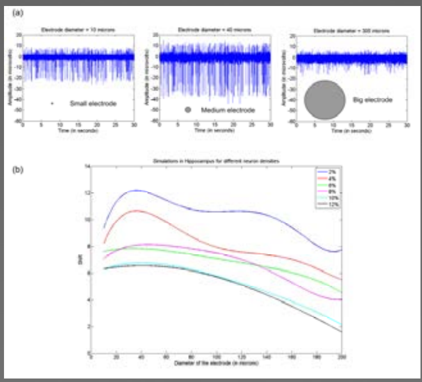
Electrode design

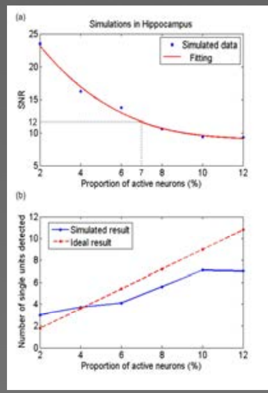


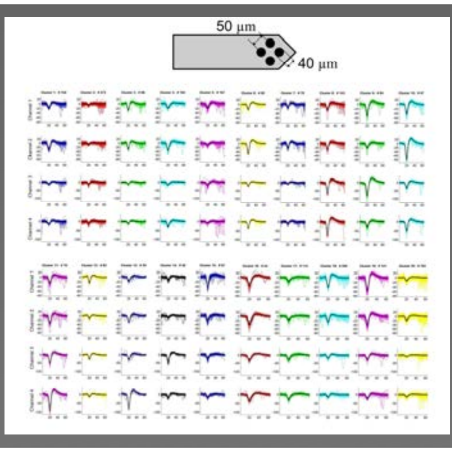


"Despite this prevalence [of the use of microelectrodes for single cell recordings] there remains a good deal of mystery about how best to make these electrodes and how to interpret the extracellular potentials that they record. The attitude of many practical users is the sensibly pragmatic one of the biological assay. When one finds some method of making microelectrodes that successfully isolate units in a given neuronal structure, one 'freezes the design' and attends to the more important task of collecting neural data"

D. Robinson, 1968

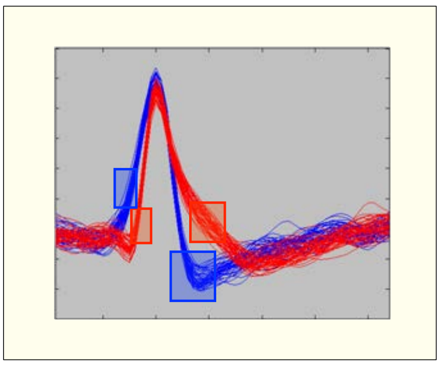






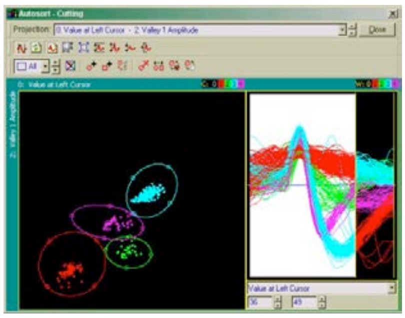
Spike sorting

Window discriminators



Scholarpedia, 2007

Cluster cutting



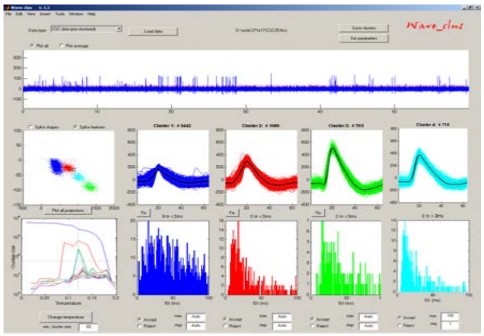
Disadvantages:

- Supervised
  - not practical for many channels, may need readjustment
- Hard to set if spike shapes overlap
- May miss sparsely firing neurons

Our goal

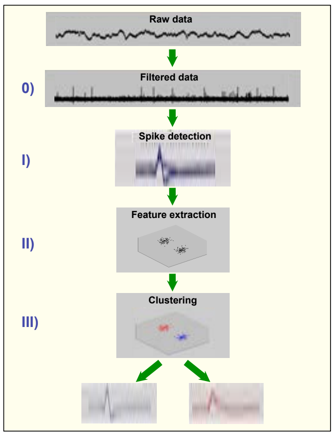
- Algorithm for automatic detection and sorting.
- Relatively fast.
- Improve both detection and sorting in comparison with previous approaches.

Wave_clus



www.le.ac.uk/csn

Neural Computation 2004

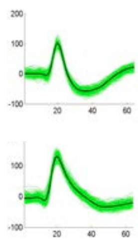


Neural Computation 2004
Scholarpedia 2007
Nat. Rev. Neurosci 2009
Current Biology 2012

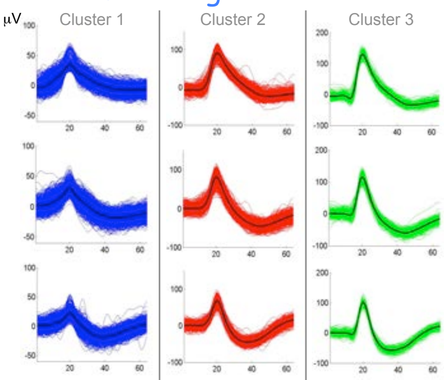
0 - Filtering

- Use of offline noncausal filters

No phase distortions!

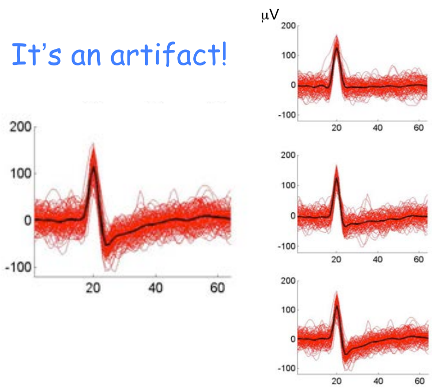


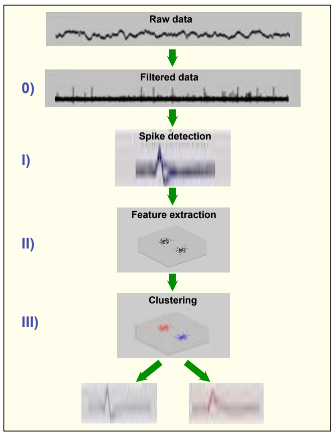
Filtering distortions



Quian Quiroga. J.Neuroscience Methods 2009

It's an artifact!





I - Spike detection

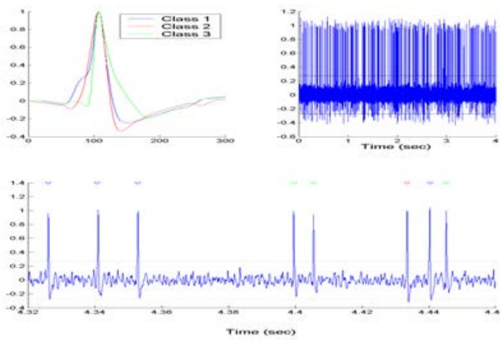
- Set an automatic amplitude threshold

$$T = 4 \cdot median\left\{\frac{|x|}{0.6745}\right\}$$

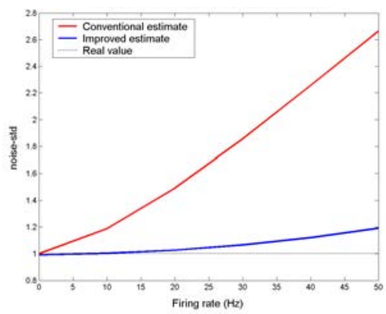
- Spikes are aligned after interpolation with cubic splines.

Simulated data

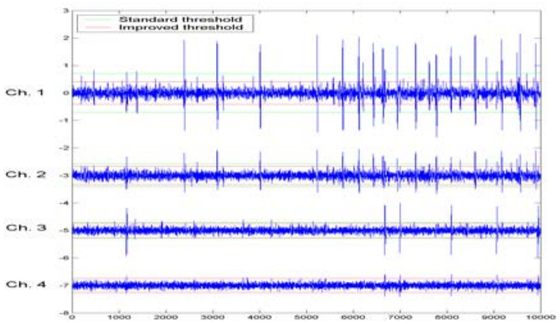
Ex. 2



Std estimation



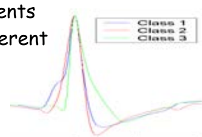
Locust data (from Ofer Mazor & Giles Laurent)



Scholarpedia 2007

II - Feature extraction: wavelets

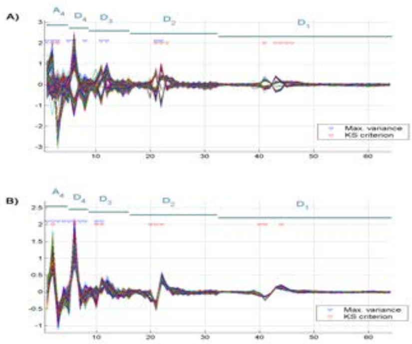
- Wavelet Transform: is a time-frequency decomposition of the signal with optimal resolution both in time and frequency.
- Key idea: a few wavelet coefficients will be able to separate the different spike classes.



Wavelet coefficients

Ex 1

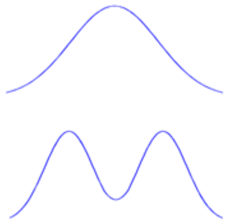
Ex 2



II a - Selection of wavelet coefficients:

KS test of Normality

Distribution of a given
Wavelet coefficient



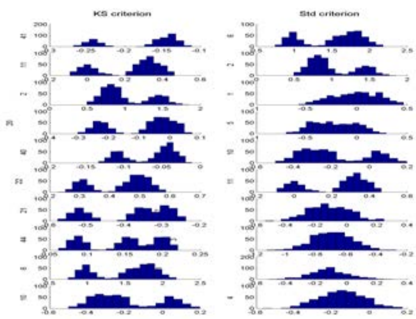
No separation

Good separation

II a - Selection of wavelet coefficients:

KS test of Normality

Ex 2



Projections into the feature space

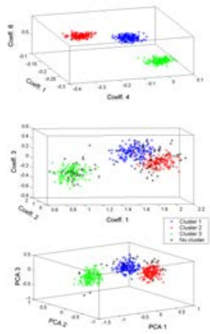
Ex 2

Misses

1/507 (0.2%)

134/507 (26.4%)

32/507 (6.2%)

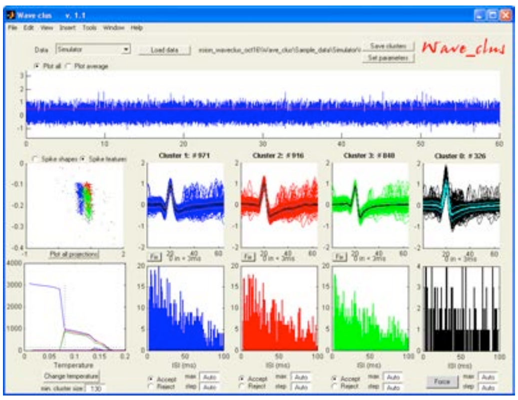


KS criterion

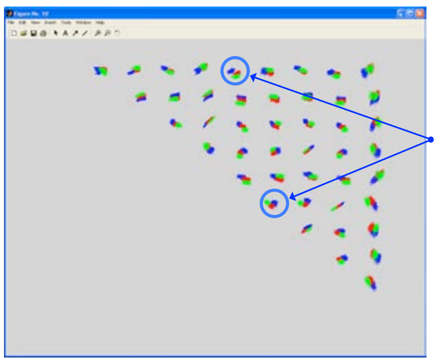
STD criterion

First 3 PCs

Another example… with wavelets.

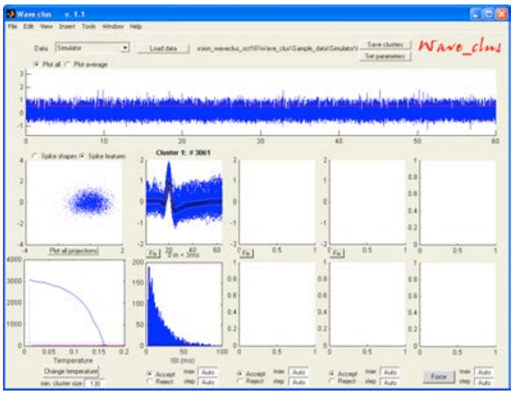


All projections…



Clusters separate clearly
in some projections

... and now with PCA



III – Super-paramagnetic clustering

- Automatic clustering algorithm based on ideas from statistical mechanics.
- It's based on nearest-neighbor's interactions.
- Clusters don't need to have a well-defined center, low variance or a Gaussian distribution.

Blatt et al. Phys. Rev. Lett. 76: 3251-3254; 1996.
Blatt et al. Neural Computation 9: 1805-1842; 1997.

Interaction strength

$$J_{ij} = \begin{cases} \frac{1}{K}\exp\left(-\frac{d_{ij}}{2a^2}\right) & if\ x_i, x_j\ n.n. \\ 0 & else \end{cases}$$

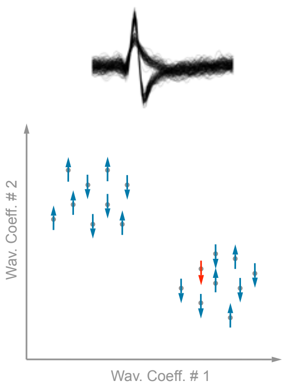
$$d_{ij} = \left\| x_i - x_j \right\|^2$$

Probability of change

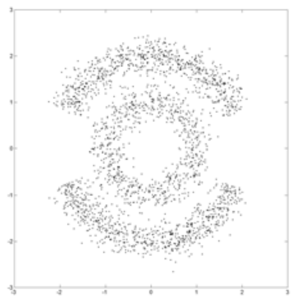
$$p_{ij} = 1 - \exp\left(-\frac{J_{ij}}{T}\delta_{s_i,s_j}\right)$$

Point-to-point correlation

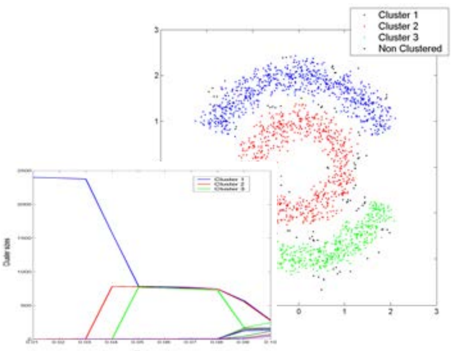
$$\left\langle \delta_{s_i,s_j} \right\rangle \geq \theta$$



Toy example



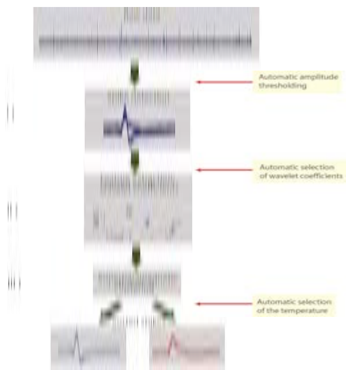
Toy example



Misses

102/2400

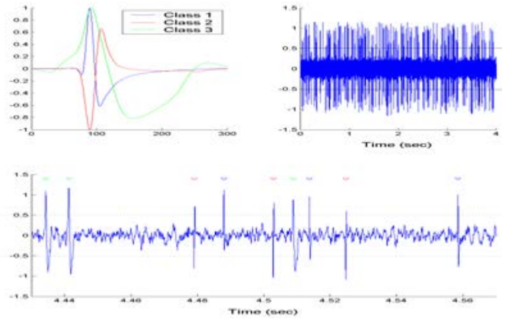
Outline of the method

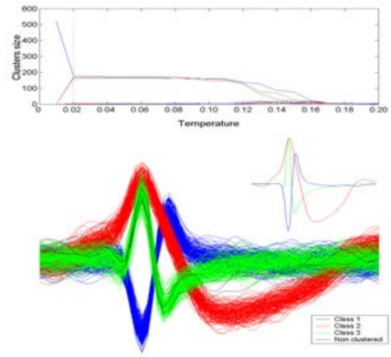


Quian Quiroga et al. Neural Computation, 2004

Simulated data

Ex 1



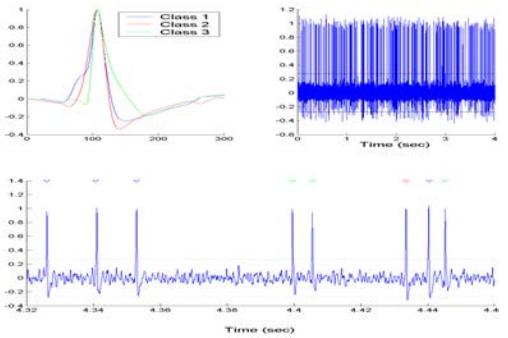


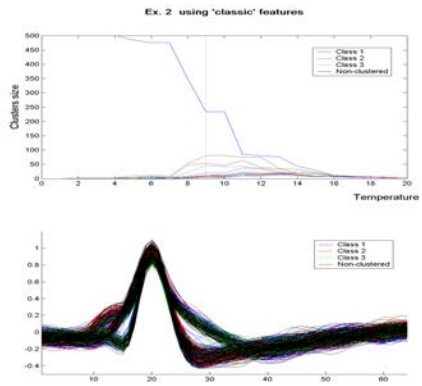
Misses

3/521

Simulated data

Ex. 2

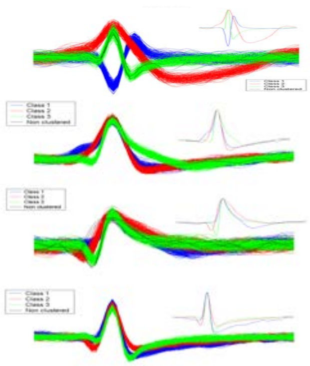




Misses

33[illegible]

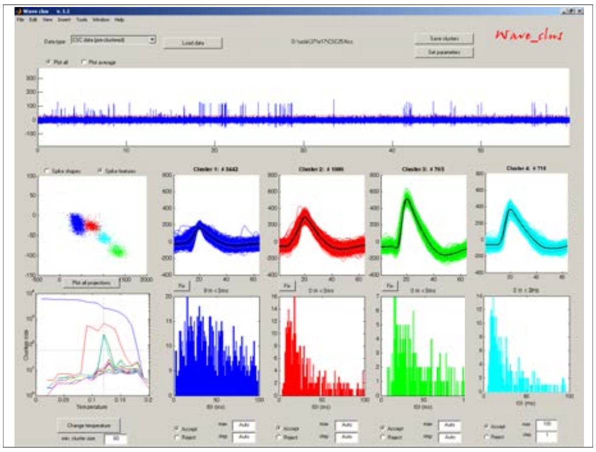
Simulation results

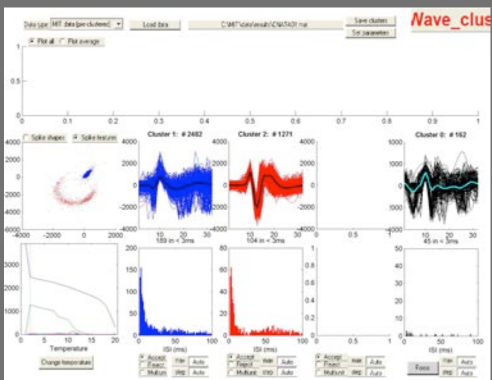


Example #	Nr. of			SPC		K -	means
[noise level]	Spikes	Wavelets	PCA	Spike shape	Feature set	Wavelets	PCA
Ex. 1 [0.05]	2729	1	1	0	863	0	0
[0.10]	2753	5	17	0	833	0	0
[0.15]	2693	5	19	0	2015 (2)	0	0
[0.20]	2678	12	130	24	614	17	17
[0.25]	2586	64	911	266	1265 (2)	69	68
[0.30]	2629	276	1913	838	1699 (1)	177	220
[0.35]	2702	483	1926 (2)	1424 (2)	1958 (1)	308	515
[0.40]	2645	741	1738 (1)	1738 (1)	1977 (1)	930	733
Ex. 2 [0.05]	2619	3	4	2	502	0	0
[0.10]	2694	10	704	59	1893 (1)	2	53
[0.15]	2648	45	1732 (1)	1054 (2)	2199 (1)	31	336
[0.20]	2715	306	1791 (1)	2253 (1)	2199 (1)	154	740
Ex. 3 [0.05]	2616	0	7	3	619	0	1
[0.10]	2638	41	1781	794	1930 (1)	850	184
[0.15]	2660	81	1748 (1)	2131 (1)	2150 (1)	859	848
[0.20]	2624	651	1711 (1)	2449 (1)	2185 (1)	874	1170
Ex. 4 [0.05]	2535	1	1310	24	1809 (1)	686	212
[0.10]	2742	8	946 (2)	970 (2)	1987 (1)	271	579
[0.15]	2631	443	1716 (2)	1709 (1)	2259 (1)	546	746
[0.20]	2716	1462 (2)	1732 (1)	1732 (1)	1867 (1)	872	1004
Average	2662	232	1092	873	1641	332	371

Quian Quiroga et al. Neural Computation, 2004

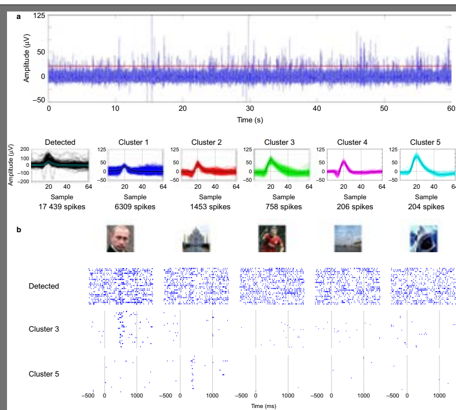
Real data





Do we need spike sorting?

Epilepsy surgery



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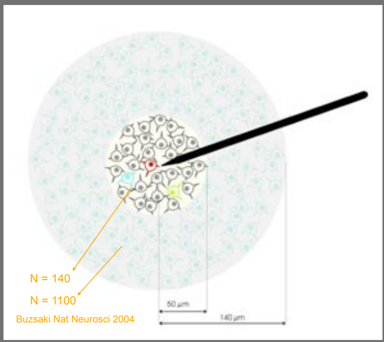
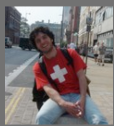
How many neurons can we see?





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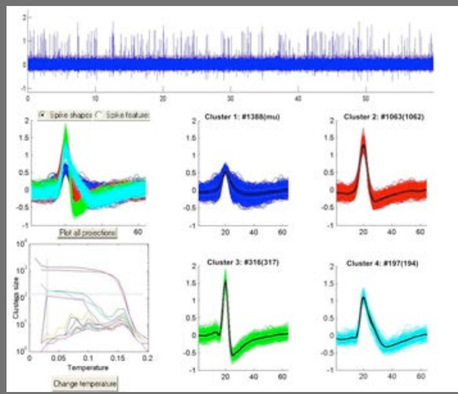

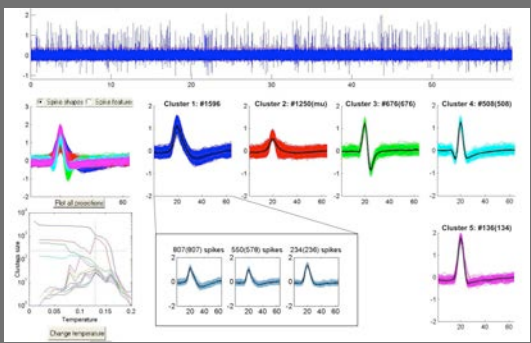

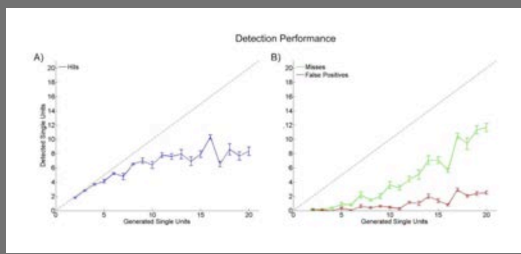

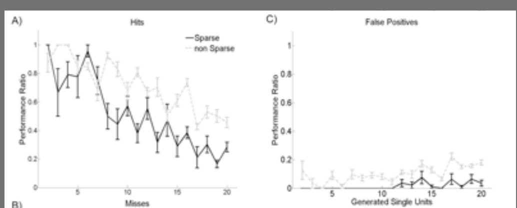

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