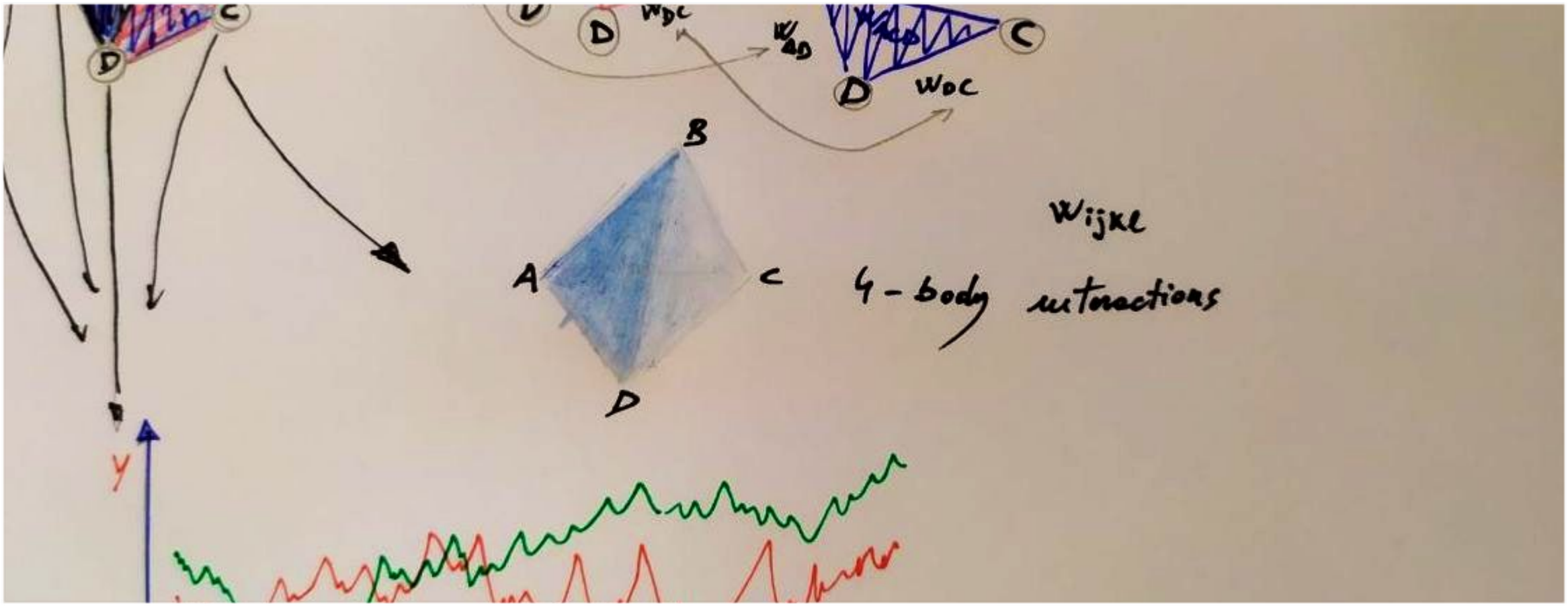

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European Researchers' Night

Topological data analysis in life (and social) science: from detecting an epileptic seizure to early warning in financial market

Marco Piangerelli, Ph.D.

Università di Camerino

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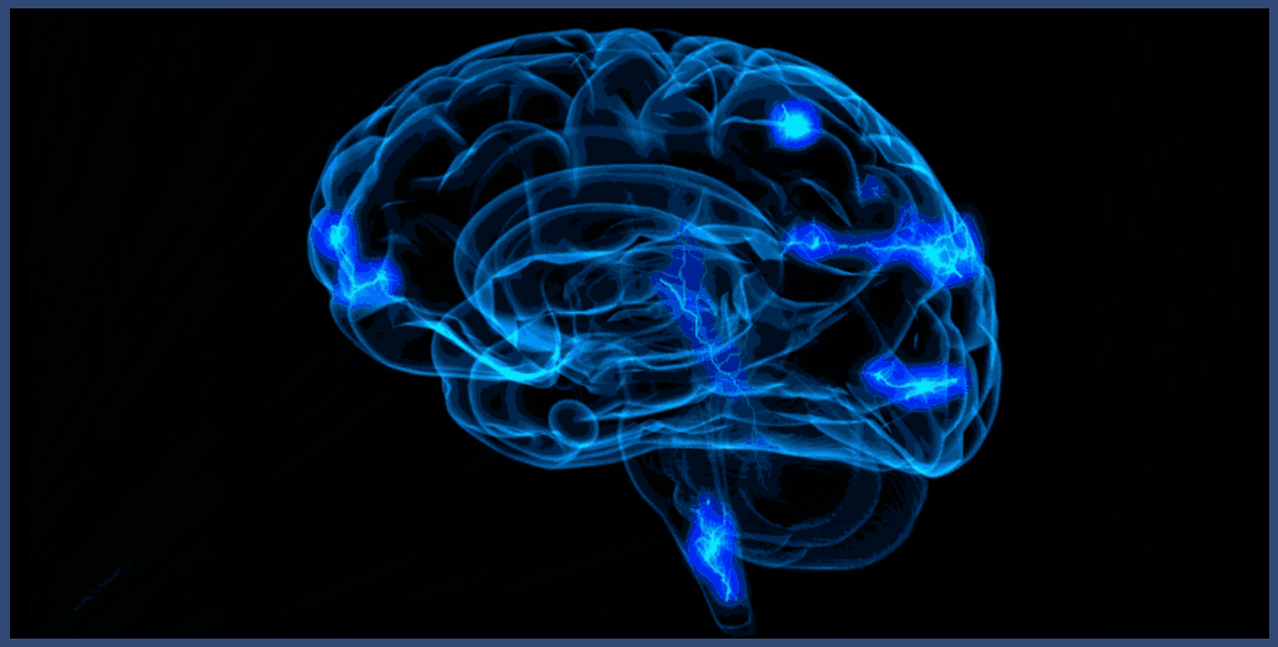
What are Complex Systems?

Complex systems are characterized by “emergent behavior”

Two examples of Complex systems



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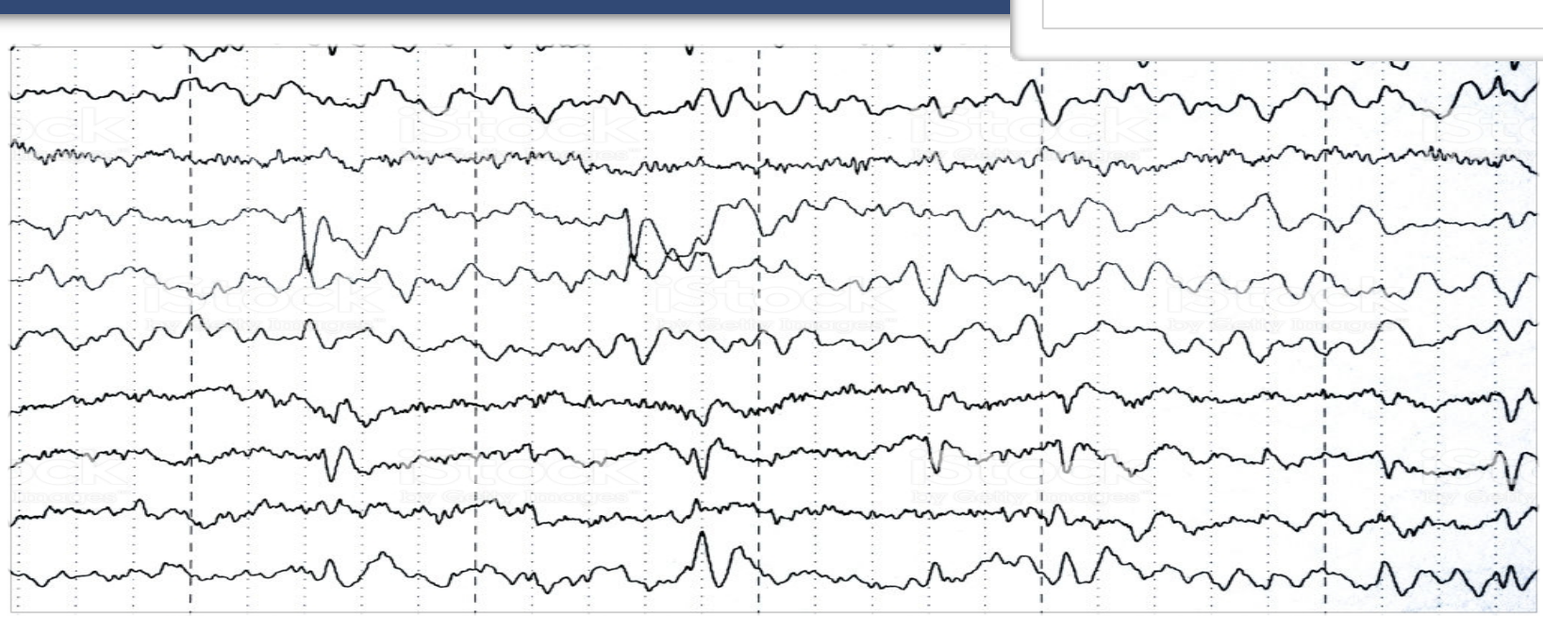
What kind of data are we deal with?



Time series are collections of values in time

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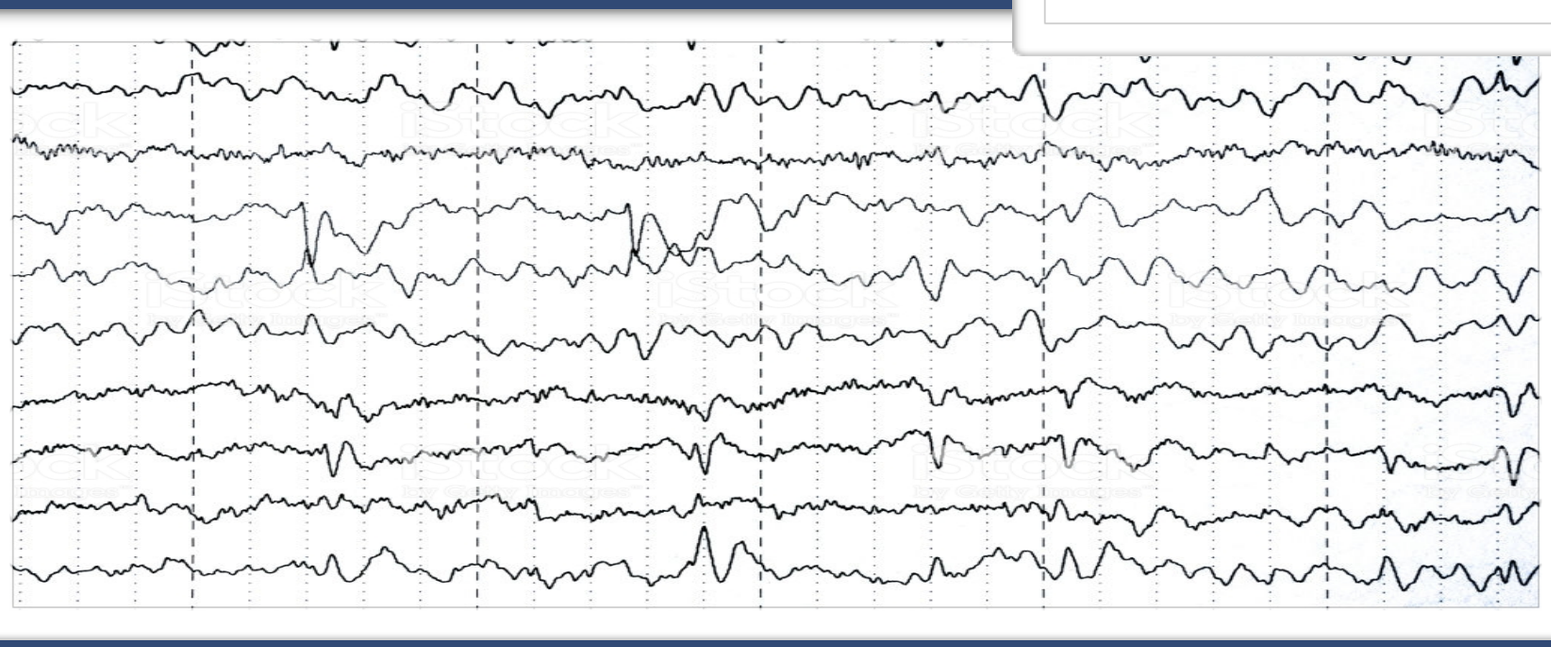
What kind of data are we deal with?



What are emergent behaviors for such systems?

What kind of data are we deal with?

Financial Crisis

Epileptic Seizures

What are emergent behaviors for such systems?

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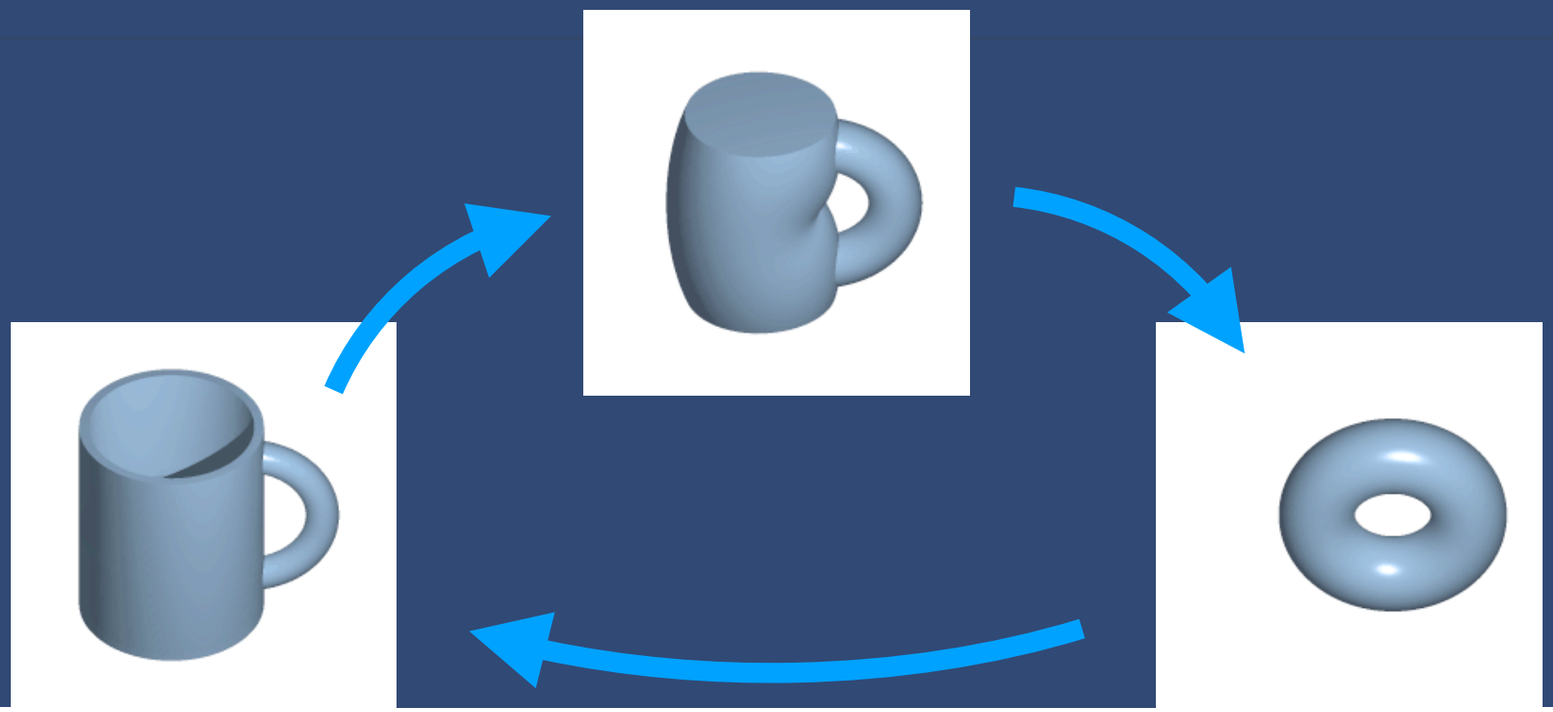
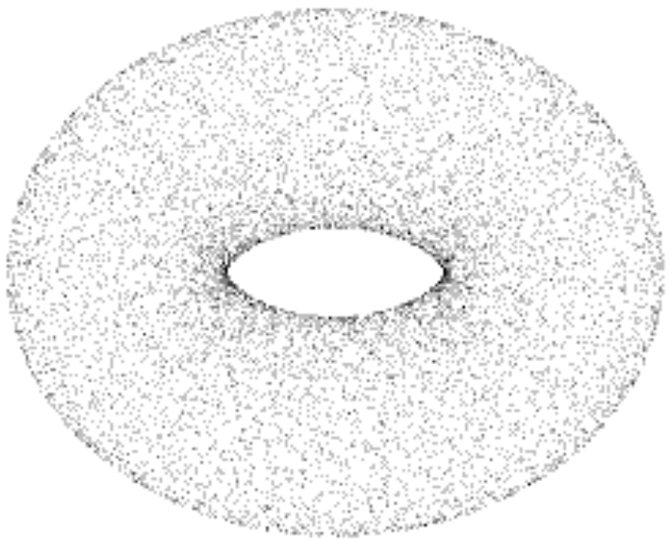
Emergent Behavior are Global Behavior

For being able to detect Emergent Behaviors we need techniques that takes into account the system in its “Globality”

Topological Data Analysis can do that

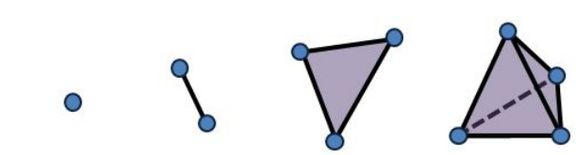
TDA



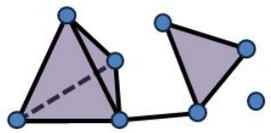


Background

A **simplicial complex** is built from points, edges, triangular faces, etc.

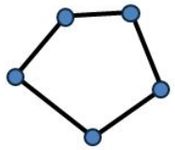


0-simplex 1-simplex 2-simplex 3-simplex (solid)

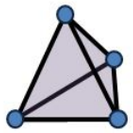


example of a simplicial complex

Homology counts components, holds, voids, etc.



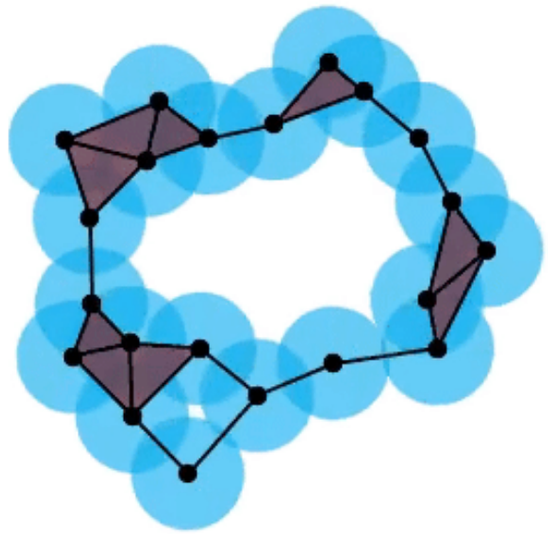
hole



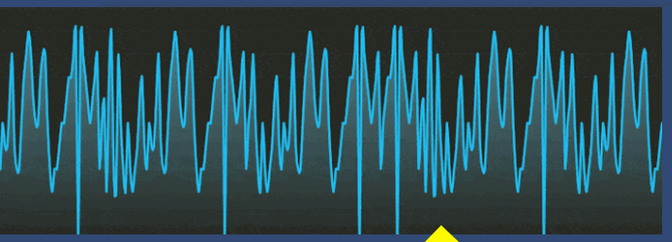
void
(contains faces but empty interior)

TOPOLOGICAL INVARIANTS

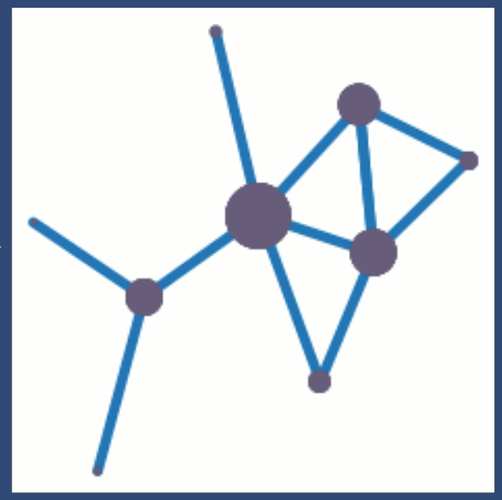
Homology of a simplicial complex is computable via linear algebra.



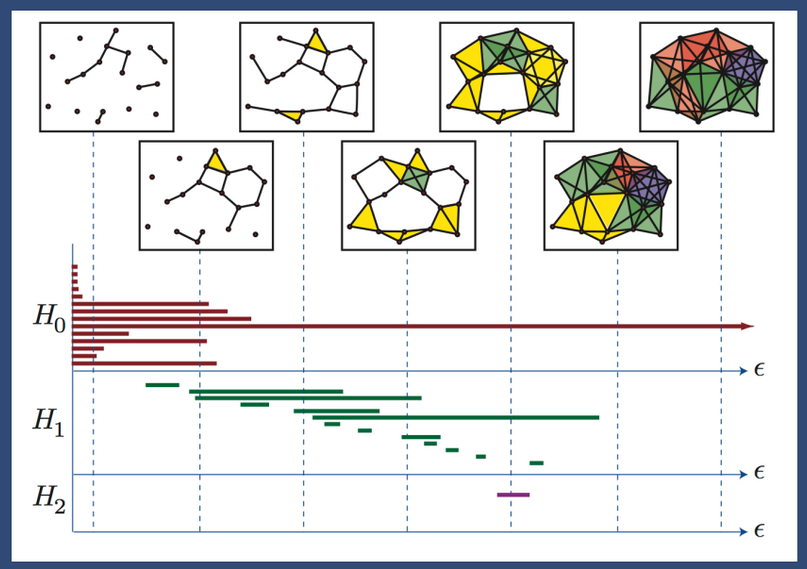
Analysis Pipeline



1. From time series to graph

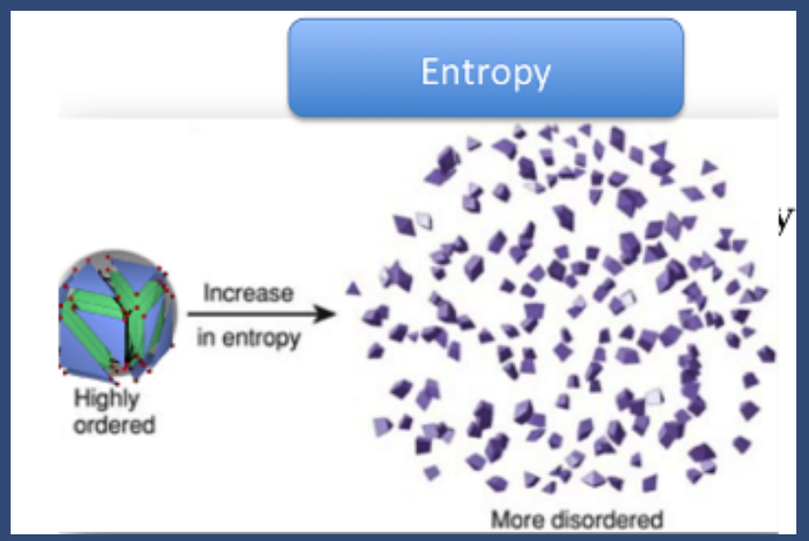


2. From graph to simplicial complexes and barcodes (TOPOLOGICAL INVARIANTS)

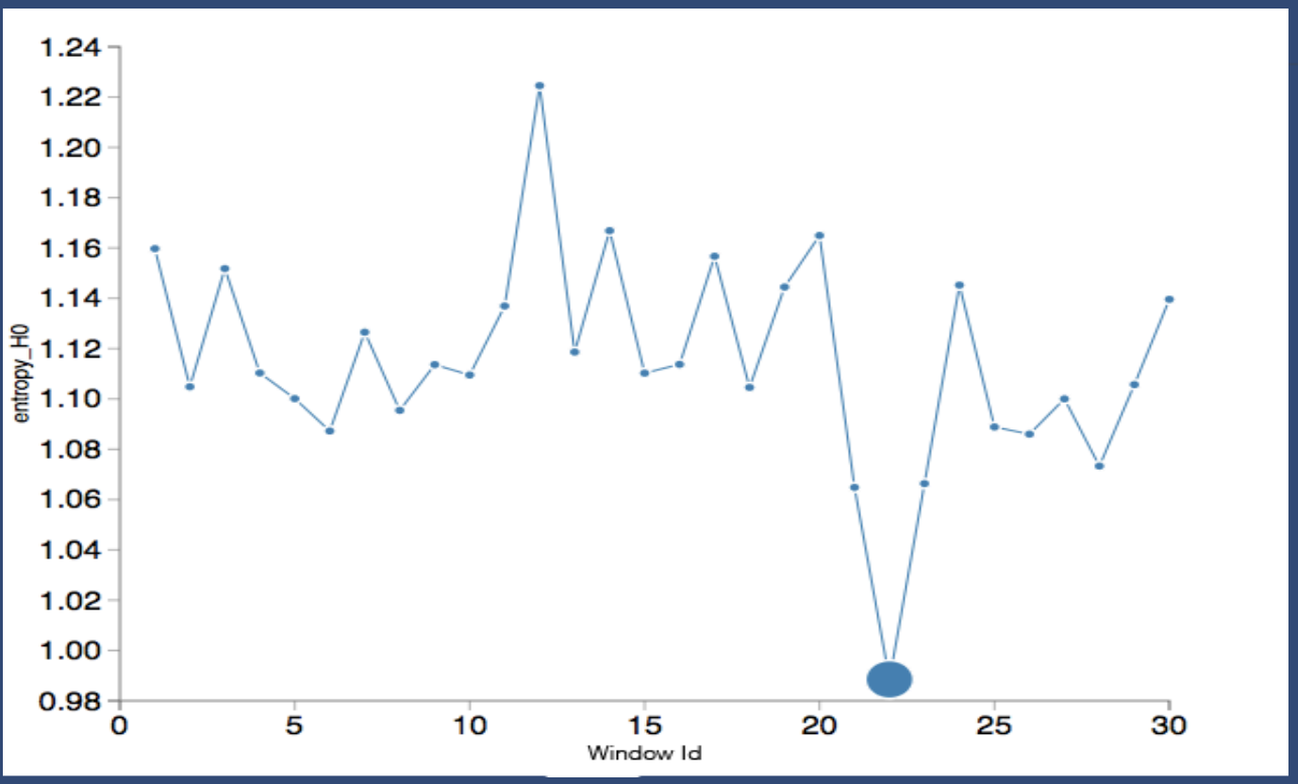


3. From barcodes to (persistent) Entropy

Quantification of Topological Invariants

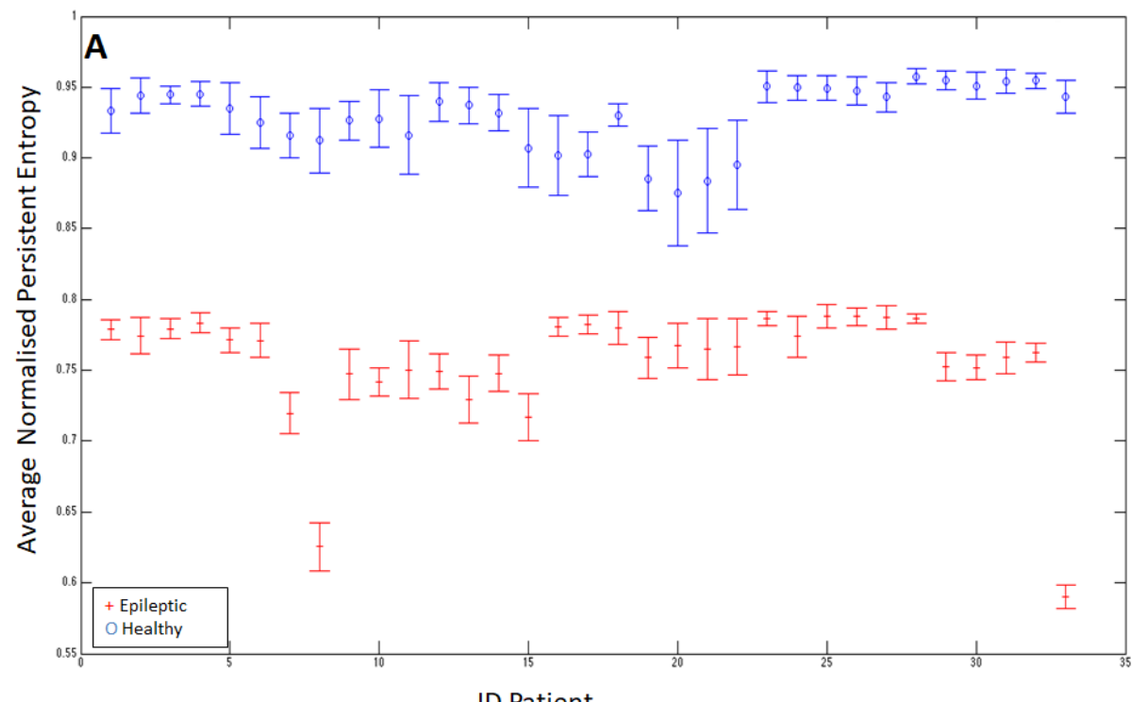


Seizures Detection



The variation of Entropy let us
To detect seizure in a EEG trace

The variation of Entropy let us
To distinguish epileptic EEG trace
From the non epileptic ones



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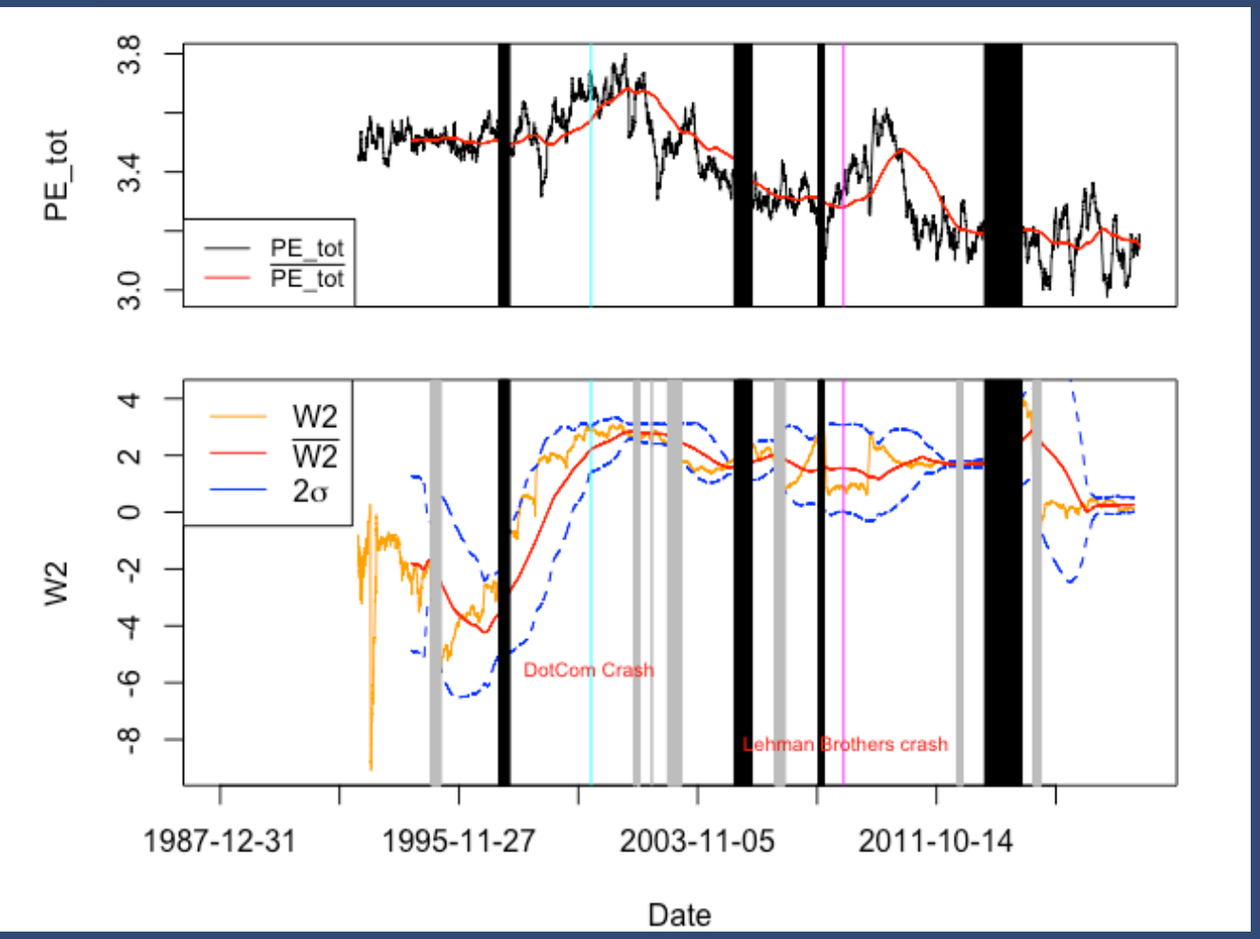
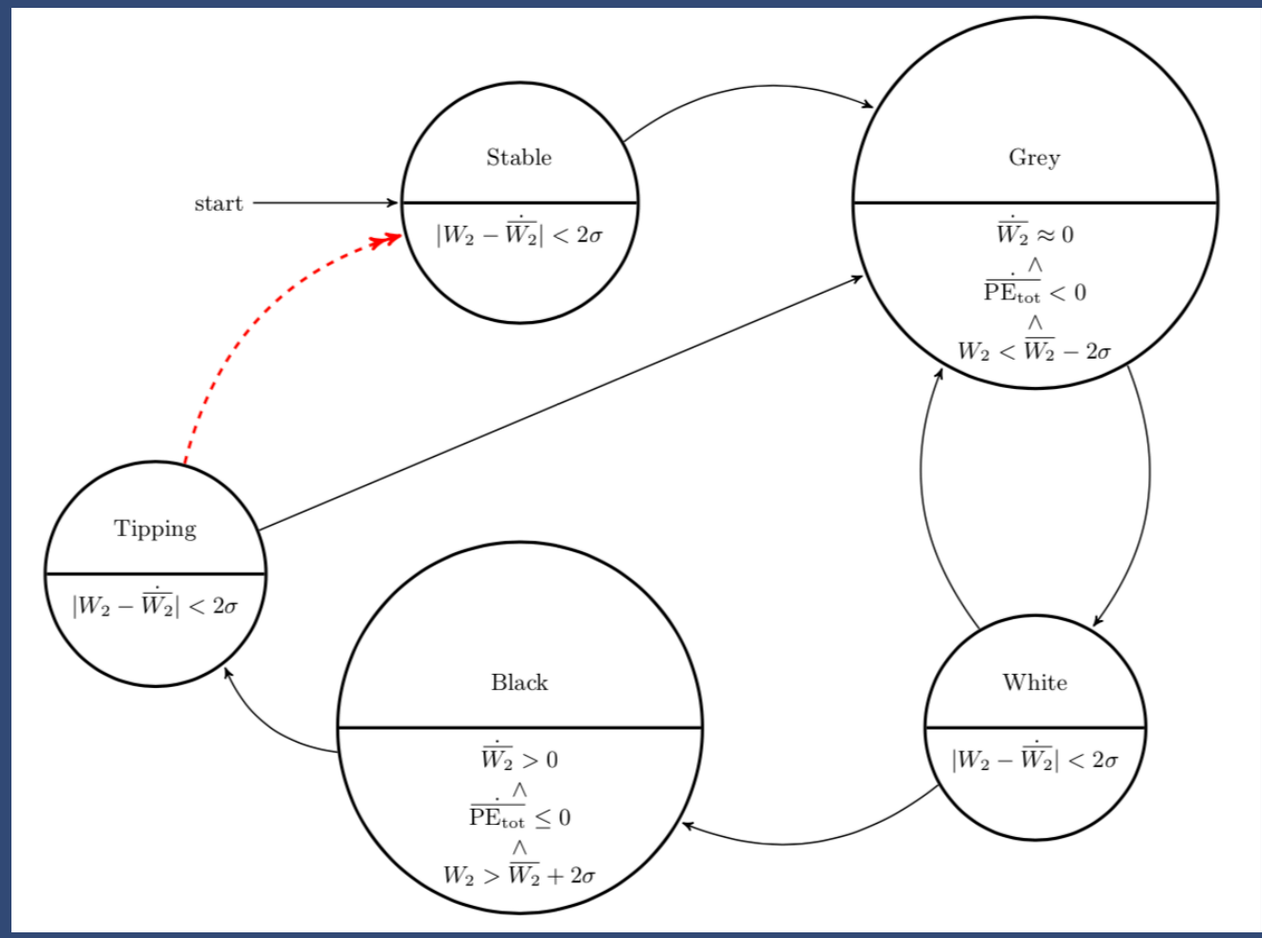
Financial Crisis: W2-Pea



The variation of Entropy let us
To detect regimes changing allowing
Us to derive an automaton:
The W2-Pea

The W2-Pea describes the
Evolution of the system and the
Onset of a Financial crisi
After a particular sequence
of different regimes