CHIST-ERA - From data to new knowledge

COMPLEX NETWORKS EMERGING FROM LARGE DYNAMIC DATABASES

New mathematical and computational tools

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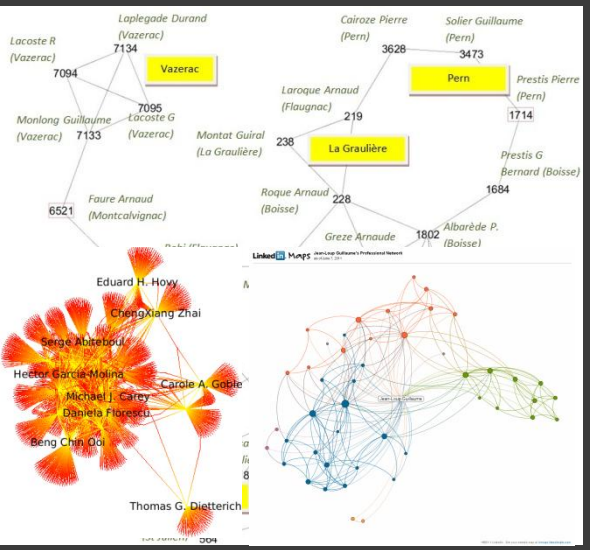
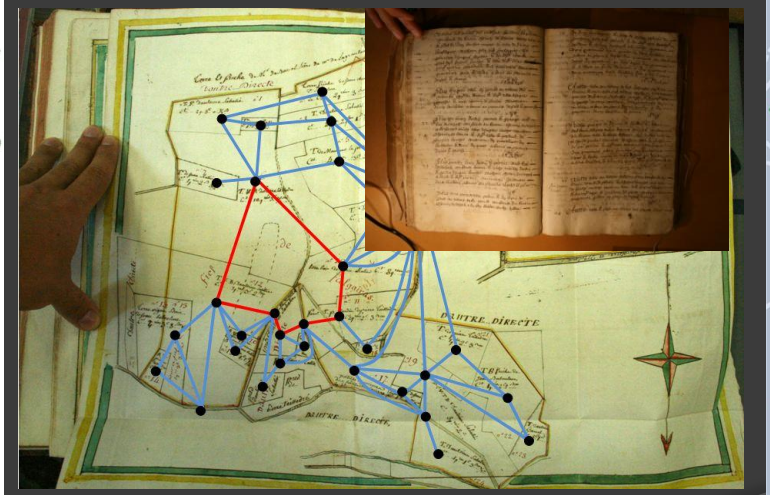
From large databases to complex networks

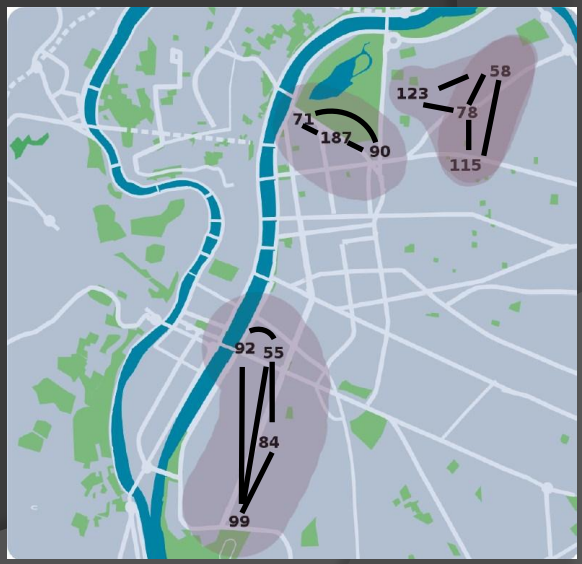
In many experimental data sets, some information can be modeled as interaction networks.



Social networks



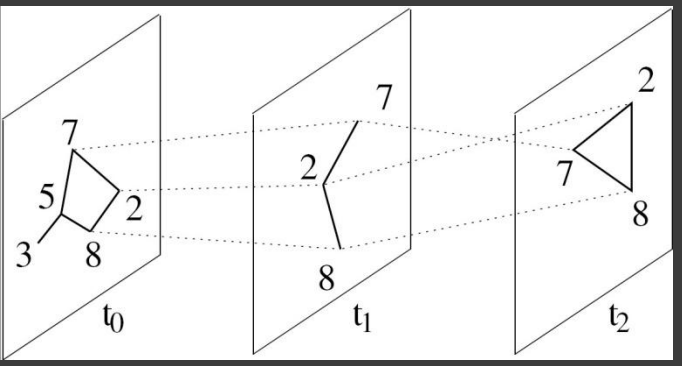
Landscape organisation



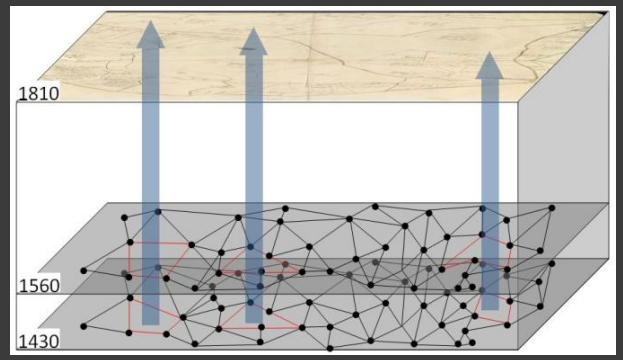
Velo'v

Dynamics properties of dated networks

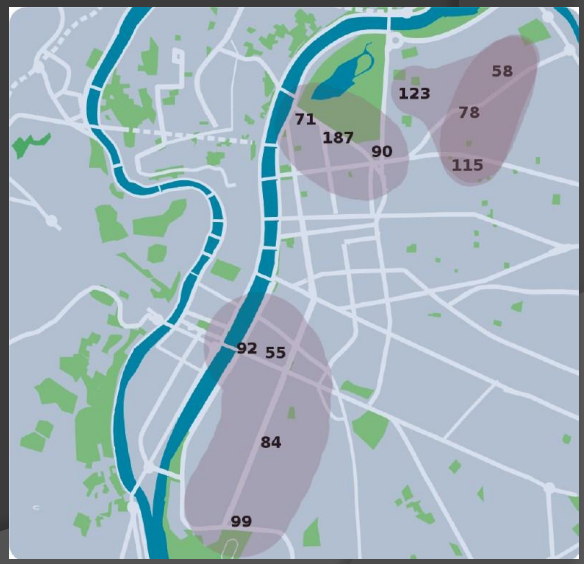
- The nodes are entities that may evolve over time (appearance, disappearance, change).
- The links are dated interactions



Social network evolution



dynamics of landscape fragmentation

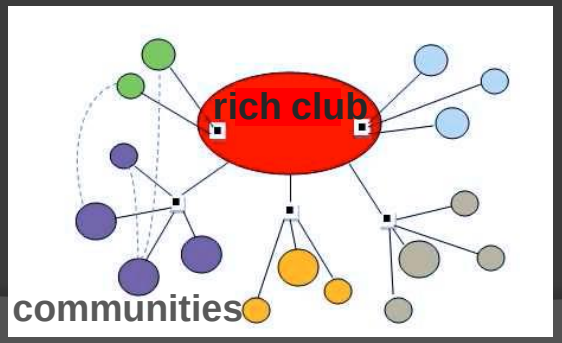


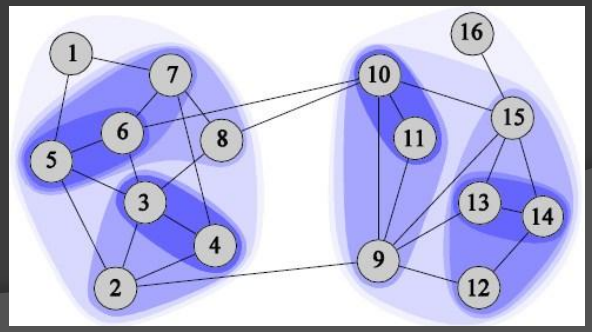
Velo'v

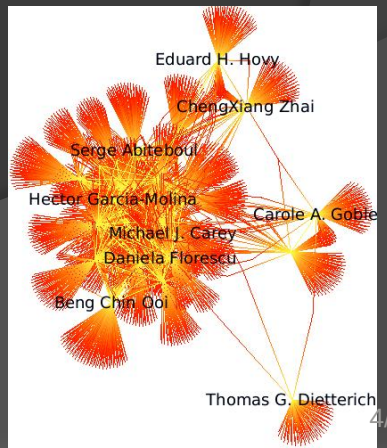
Multi-scale properties of networks : what is a ‘community’ ?

At a given time t_0 , a ‘community’ may be made of individuals (nodes) that have:

- similar neighbours (*i.e.* twins and complete subgraphs)
- similar neighbours outside the community (*i.e.* interval)
- the same graph distances with individuals outside the community (isometric nodes)
- …





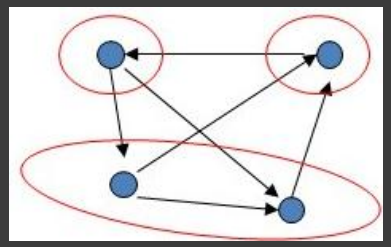


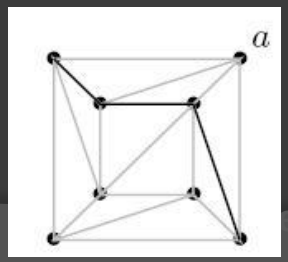
State of the art

Mathematical and computational tools provide a framework to explore and model the complex interaction networks emerging from large structured databases

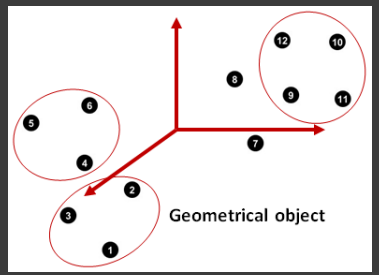
- *Static networks*

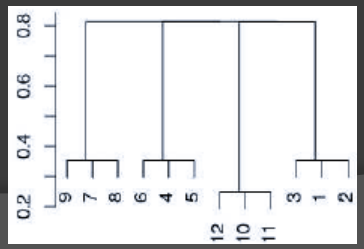
Graph theory



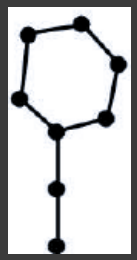


Data analysis





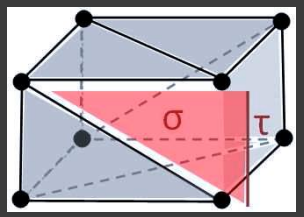
Algebra

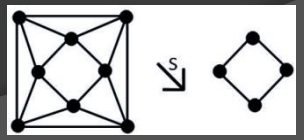


$$\begin{pmatrix} 0 & \cdots & 1 \\ \vdots & \ddots & \vdots \\ 1 & \cdots & 0 \end{pmatrix}$$

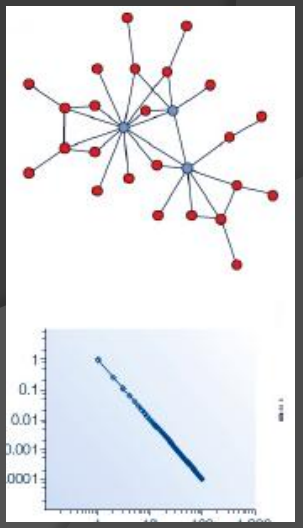
$$A \cdot u = \lambda u$$

Topology





Statistics & Probability

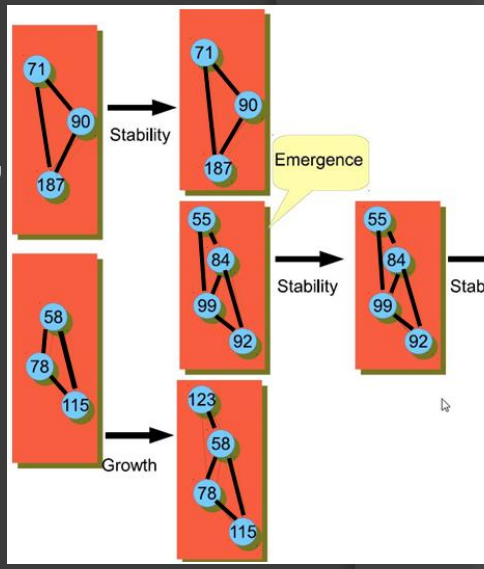


Scale free network

- *Dynamic networks*

Global approach: evolution of statistical indicators of the graph (degree, density, …).

Local approach: tracking patterns or communities, information spreading, detecting ‘events’.



Few established tools for the study and description of the dynamic :

- Most real-world networks share non-trivial static properties: is it the same for dynamic properties ?
- What is a community in a dynamic situation ? (multislice)
- Is it possible to adapt the mathematical tools to take account of time or should we create new ones ?

Scientific challenges

- Evaluate the limits of a disciplinary approach in the modeling of a complex network emerging from a large dated database (Human and Social Sciences).
- Define mathematical tools for modeling dynamics in multi-scale, hierarchical, and uncertain large networks emerging from real databases.
- Gather the scientific communities of data mining, graph theory and signal processing (statistical physics).

communities

Conclusion

- *Target outcome*

New mathematical and computational tools for modeling dynamics in real-world network, and, for instance, being able to define the notion of a community. They could be used to detect events (regular dynamics vs. anomalies) and predict evolution (link prediction, recommendation).

- *Expected impact*

- Enhancing interdisciplinary around the study of large databases.
- A better knowledge of large dynamic data in various domains.

communities