

Proposition de stage de M2
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Reconstructing temporal networks from backbones of structures

Abstract:

In many data sets, crucial information on the structure and temporality of a system coexists with noise and non-essential elements. In networked systems for instance, some edges might be non-essential or exist only by chance. Filtering them out and extracting a set of relevant connections, the "network backbone", is a non-trivial task. A number of methods have been proposed in the case of static networks [1,2], and the case of temporal networks, in which edges between nodes can appear and disappear, has recently been tackled [3]. In [3], a method was indeed proposed to extract significant ties in a temporal network, using a temporal null model as reference. The method makes it also possible to extract significant structures such as simultaneous triads of edges.

Once a backbone has been extracted, one can ask whether it contains enough information to reconstruct the original data, or at least a surrogate version that is statistically equivalent and can be used for simulations of dynamical processes in networks. While we have recently investigated this issue in the case of simple spreading models [5], it remains open for other processes such as opinion formation models or complex contagion models, in particular when such processes are based not on ties but on triads [4].

The internship will explore this issue by:

- Implementing a procedure of construction of surrogate data from a temporal network backbone [5];
- Investigating several models of diffusion and of opinion formation on temporal networks (Voter model, Naming Game for instance) and comparing them on original and surrogate data;
- Implementing complex contagion models, including the one of [4], and devising if needed new reconstruction methods from backbones adapted to processes involving higher-order interactions.

The internship could lead to a PhD on theoretical aspects of temporal networks.

Required profile: statistical physicist with good numerical (coding) skills, preferentially in python.

References

- [1] Extracting the multiscale backbone of complex weighted networks. Proc. Natl. Acad. Sci. USA 106, 6483–6488 (2009), <http://www.pnas.org/content/106/16/6483.short>
- [2] Irreducible network backbones: unbiased graph filtering via maximum entropy. <https://arxiv.org/pdf/1706.00230.pdf>
- [3] The structured backbone of temporal social ties, Nature Communications 10:220 (2019)
- [4] Simplicial models of social contagion, [Nature Communications 10:2485 \(2019\)](https://doi.org/10.1038/s41467-019-12485-2)
- [5] Building surrogate temporal network data from observed backbones, <https://arxiv.org/abs/2012.03280>