Research Internship LIP6 – Complex Networks

An Aggregation Algorithm for Multiscale Analysis of Dynamical Networks

Laboratory : Laboratoire d'Informatique de Paris 6

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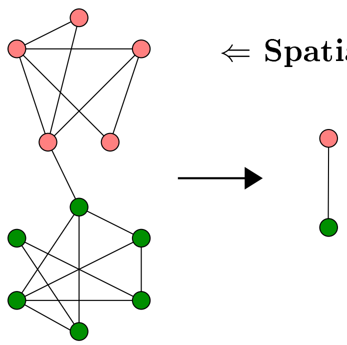
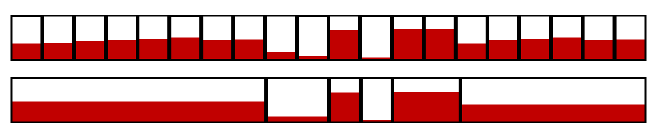
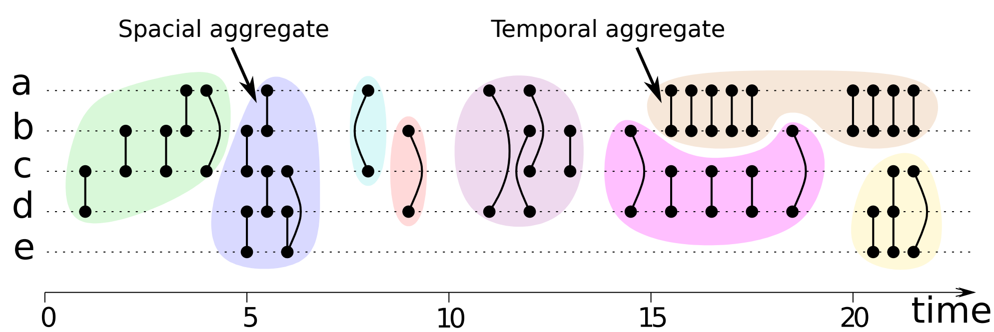


⇐ **Spatial Aggregation**

⇓ **Temporal Aggregation**



Spatiotemporal Aggregation ⇓



The optimisation of large-scale sociotechnical services (*e.g.*, transports, mobile communication, web services) requires a deep understanding of users' interactions in several domains (geographical mobility, social interactions, digital data exchanges) and at several spacial and temporal scales (from individuals to nations, from seconds to years). In this context, we aim at designing multiscale analysis methods to tackle the structural and dynamical complexity of large interaction networks.

From a formal point of view, classical tools from graph theory allows to model static networks, but they often fail to properly handle dynamical ones. This is because time and space in complex systems are strongly inhomogeneous and should hence be carefully handled. To that purpose, link streams constitute a new formalism to represent dynamical networks as genuine spatio-temporal objects: Each interaction is represented as a triplet (sender, receiver, time) allowing to fully describe the dynamics of interactions. From this formalism, and with a multiscale perspective, we aim at identifying macroscopic interaction patterns that properly summarise the microscopic link stream in order to reduce its descriptional complexity. Such pattern could correspond to local but long-term interactions (*e.g.*, in neighbourhood daily life), to global but short-term interactions (*e.g.*, viral piece of news on the internet), or to any combination of intermediate scales.

In previous work, we proposed several aggregation algorithms for multiscale analysis of structured datasets, and in particular of hierarchical systems (for spatial aggregation) and of interval sets (for temporal aggregation). These algorithms strongly rely on information-theoretical measures to define relevant scales for the analysis, by defining a trade-off between descriptional complexity and information content of aggregated data. Intuitively, the optimisation of this parametrized trade-off results in (1) the aggregation of patterns that are homogeneous in space and time and (2) the detection of irregularities that arise at different scales in the data. This research project aims at developing and applying similar algorithms to the aggregation of link streams in order to provide consistent methods for multiscale analysis of dynamic networks.

We will focus in particular on:

1. The formal structure of link streams in order to define relevant macroscopic patterns that might arise in space and time.

2. The application of classical information-theoretical measures to link stream aggregation (*e.g.*, Shannon entropy, Kullback-Leibler divergence)

3. The design of an algorithm to detect feasible patterns that optimise these measures, and its implementation.

4. The detection of these patterns in real-world large scale data (*e.g.*, IP trafic, email exchanges, contact networks).

References

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