Multiplex stream graphs

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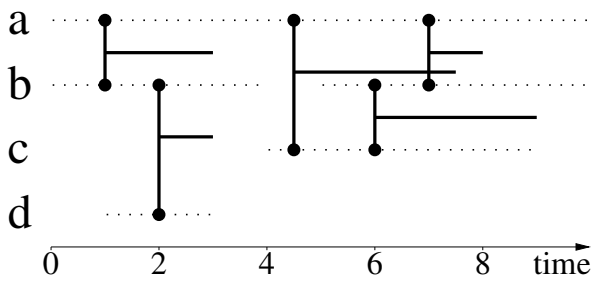


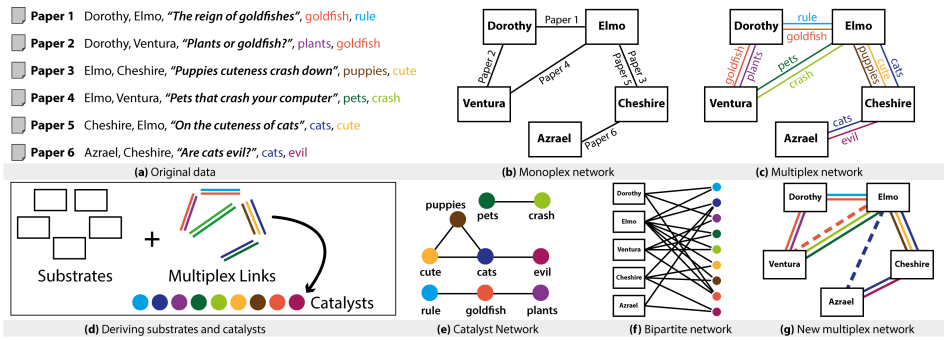
1 Context

An interaction is a triplet (t, u, v) meaning that two entities, u and v, interacted together at time t. Examples of real-life interaction streams are manyfold: message exchanges between individuals (emails), packet transfers on a network, phone calls, or contacts between individuals equipped with sensors. Such objects are therefore crucial in a variety of applications, including statistical analysis, anomaly detection and recommender systems, among many others.

Stream graphs [3] are a recent theoretical advance to bridge the gap between classical graph theory and signal processing for the modelling of interactions. The foundational concepts of complex network analysis, such as density, the degree distribution, k-cores, or paths and centralities have been extended. For example, the *density* of a stream graph is the probability, when one takes two nodes and a time t at random, that those nodes are interacting at t. Searching for dense groups [6, 5] or predicting activity [4] are examples of applications.

Multilayer networks [2] are a formalism to unify the different models complex real-world graphs: sequences of graph snapshots, hypernetworks, interacting networks are all examples of objects that can be generalized as a multilayer network. The authors then go beyond the network definition, and generalize isomorphisms [1], for example.

Currently, one lacks the possibility to properly define multiplex stream graphs; however, extending the properties defined on stream graphs to multilayer networks would help gain valuable insights on real-world datasets. As the authors of [2] note, the complexity of real-world phenomenae calls for more than simple, undirected (stream) graphs, even though they provide a decent approximation.



2 Goals and requirements

The goal of this internship is to devise a formal framework for multiplex stream graphs, based upon the state-of-the-art in both domains. First, the intern will familiarize themselves with the literature in both domains. They will then be guided into devising a theoretical foundation for multiplex stream graphs, and into extending classical stream graphs notions to those new objects.

3 Details and contact information

The internship will take place in Tokyo, Japan. Plane tickets (there-and-back), as well as a monthly allowance will be provided.

For further information or to apply, please contact `tiphaine.viard@riken.jp` with your resume.

References

[1] Kivelä, M., Porter, M. A. (2018). Isomorphisms in multilayer networks. IEEE Transactions on Network Science and Engineering, 5(3), 198-211.

[2] Kivelä, M., Arenas, A., Barthelemy, M., Gleeson, J. P., Moreno, Y., Porter, M. A. (2014). Multilayer networks. Journal of complex networks, 2(3), 203-271.

[3] Latapy, M., Viard, T., Magnien, C. (2017). Stream graphs and link streams for the modeling of interactions over time. arXiv preprint arXiv:1710.04073.

[4] Arnoux, T., Tabourier, L., Latapy, M. (2018). Predicting interactions between individuals with structural and dynamical information. arXiv preprint arXiv:1804.01465.

[5] Himmel, A. S., Molter, H., Niedermeier, R., Sorge, M. (2017). Adapting the Bron–Kerbosch algorithm for enumerating maximal cliques in temporal graphs. Social Network Analysis and Mining, 7(1), 35.

[6] Gaumont, N., Magnien, C., Latapy, M. (2016). Finding remarkably dense sequences of contacts in link streams. Social Network Analysis and Mining, 6(1), 87.