

Project funded by an ANR grant

Subject: Multi-scale classification and analysis of data on networks

Laboratory : LP-ENSL (Laboratory of Physics) & LIP (Computer Science Lab.),
ENS de Lyon
46 allée d'Italie, 69364 Lyon cedex 07

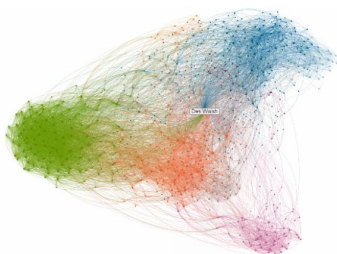
PhD directors: Pierre Borgnat (CR CNRS HDR) & Paulo Gonçalves (DR INRIA HDR)
Emails: Pierre.Borgnat@ens-lyon.fr, Paulo.Goncalves@ens-lyon.fr
SiSyPhe and DANTE teams
Phone number: 04 72 72 86 91
Web: <http://perso.ens-lyon.fr/pierre.borgnat>
<http://perso.ens-lyon.fr/paulo.goncalves/>

Keywords: signal processing, networks, graph wavelets, semi-supervised learning, clustering

Description

In a growing number of scientific studies, it is necessary to add to the data a description layer in terms of networks: it is true when studying transportation networks, biological networks, social networks, sensor networks, Internet networks [New10, BBV08]. or even images possibly with irregular samples, or only point samples [LG12]. For processing these data having a structure of relational properties encoded by networks, the field of data processing on networks is emerging [SNF⁺13] and needs to rely jointly on approaches from computer science, physics and signal processing. Also, the applications are wide, ranging for instance from epidemiological studies [GGF13] to social studies [TB14] or transportation [MBP⁺14], to limit the list to works conducted in the group proposing the subject.

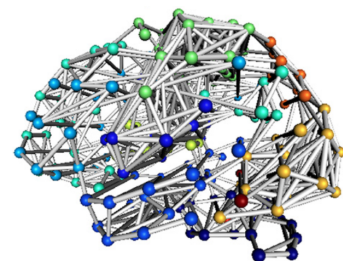
Elaborating on our previous works conducted about multiscale community detection in networks [TB14] and semi-supervised learning on graphs [GGFSM14], a main idea proposed for this PhD is generally study graph-based multiscale processing, transformations and filtering of data on networks. For that, one fruitful idea is to consider that many detection, segmentation or estimation problems for data on graphs can be represented as a problem of learning, or of classification, with a varying degree of supervision. Community detection in complex networks is usually a fully unsupervised learning while classification of data in Internet network is often supervised (for interpretability). An objective of the



Linked-In social network



3D Color Point Cloud



fcMRI Brain Network

PhD project will be to probe how semi-supervised learning (SSL) [AGMS12] can be designed for data in graphs in a way to fall between supervised and unsupervised cases.

This PhD project will be conducted in the DANTE and Sisyphe teams of the laboratory of computer science (LIP) and physics (LP) from the ENS de Lyon. These two teams are partially collocated in the IXXI (Rhône-Alpes Complex Systems Institute, www.ixxi.fr) at the ENS de Lyon. The support of the project is provided by an ANR grant on Graph Data and Signal Processing with the GREYC (Caen), GIPSA-lab (Grenoble) and LIGM (Marne-la-vallée), that will provide a framework for the project.

The novelties and challenges of the PhD project are that we need to think about processing in a multiscale and possibly in a distributed manner across the network, so as to be able to confront with the increasing mass of data that are often at hand. For that, representation and transformation of signals on graphs will be studied, e.g. wavelets or other types of graph filtering (including SSL); methods for joint processing of graph and data of graphs will be also a focus of the project. A possible development will also be provided by looking at the specific issues of temporal networks [HS12], for which it can be fruitful to study adaptive and possibly online methods of graph SSL.

While the work is to be methodological first, there is a strong motivation to go toward some applications in which the teams are active: study of social networks (or related to human activities such as transportation networks) which are a major application domain of the DANTE and Sisyphe teams; processing of 3D color point clouds acquired using 3D laser scanners, LIDAR (Light Detection And Ranging), stereos cameras and structured light sensors (in interaction with the GREYC, Caen); or computational neuroimaging where the objective is to provide a better picture of the dynamics and functional networks of the human brain through fMRI, MEG or ECG measurements (in interaction with the GIPSA-lab, Grenoble). The specific choice of the application will depend on the motivations of the candidate and of the opportunities.

The PhD candidate will have a background in signal & image processing, computer science and/or physics for complex networks. The project is conducted jointly in the physics and computer science laboratories, in the ED Infomaths or PHAST of the University of Lyon.

References

- [AGMS12] K. Avrachenkov, P. Gonçalves, A. Mishenin, and M. Sokol. Generalized optimization framework for graph-based semi-supervised learning. In *SIAM Data Mining*, 2012.
- [BBV08] A. Barrat, M. Barthlemy, and A. Vespignani. *Dynamical processes on complex networks*. Cambridge University Press, 2008.
- [GGF13] B. Girault, P. Gonçalves, and E. Fleury. Graphe de contacts et ondelettes : étude d’une diffusion bactérienne. In *Proceedings of the 24th Colloquium GRETSI*, 2013.
- [GGFSM14] B. Girault, P. Gonçalves, E. Fleury, and A. Singh Mor. Semi-supervised learning for graph to signal mapping: a graph signal wiener filter interpretation. In *IEEE Int. Conf. on Acoust. Speech and Sig. Proc.*, Firenze (Italy), May 2014.
- [HS12] P. Holme and J. Saramäki. Temporal networks. *Physics Reports*, 519(3):97–125, 2012.
- [LG12] O. Lezoray and L. Grady, editors. *Image Processing and Analysis with Graphs. Theory and Practice*. CRC Press, 2012.
- [MBP⁺14] G. Michau, P. Borgnat, N. Pustelnik, P. Abry, A. Nantes, and E. Chung. Estimating link-dependant origin-destination matrices from sample trajectories and traffic counts. preprint, September 2014.
- [New10] M. E. J. Newman. *Networks: An Introduction*. Oxford University Press, 2010.
- [SNF⁺13] D. Shuman, S.K. Narang, P. Frossard, A. Ortega, and P. Vandergheynst. The emerging field of signal processing on graphs: Extending high-dimensional data analysis to networks and other irregular domains. *IEEE Signal Processing Magazine*, 30(3):83–98, 2013.
- [TB14] N. Tremblay and P. Borgnat. Graph wavelets for multiscale community mining. *Signal Processing, IEEE Transactions on*, 62(20), October 2014.