Fast Fourier Transform on Graphs

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Duration. 2-3 months.

1 Context

Nowadays, more and more data natively "live" on the vertices of a graph: brain activity supported by neurons in networks, traffic on transport and energy networks, data from users of social media, complex 3D surfaces describing real objects... Although graphs have been extensively studied in mathematics and computer science, a "signal processing" viewpoint on these objects remains largely to be invented. As such, "signal processing on graphs" (SPG) is an emerging topic, that has already lead to pioneering theoretical and practical work to formalize foundational definitions and tools. They can be overviewed for instance from [1]. This has opened the path to many exciting future research, calling to revisit most of the usual signal processing tasks (filtering, denoising, compression, etc.).

Among signal processing tools, Fourier transform plays naturally a key role. Thanks to spectral graph theory, a Fourier transform can be defined on graphs from the eigen decomposition of the graph's Laplacian operator. However, this baseline definition does not directly leads to a *fast* implementation of the transform, which would counterpart nicely the usual Fast Fourier Transform (FFT) on time-series or images for instance. PANAMA team has recently explored new techniques to learn fast implementations of signal transforms that can be represented by a matrix multiplication, by means of a sparse factorization of this matrix [2]. Classical Fourier transform and its usual FFT implementation easily falls into this framework.

2 Goals

The main goal of this internship is to investigate on the possibility to adapt this fast transform learning strategy to Fourier transform of signals on graphs.

In a first step, the candidate will perform bibliographic work to get familiar with signals on graphs theory, concepts and tools. He/she will handle GSPBOX, a Matlab toolbox for SPG developed at EPFL [3], and will particularly focus on Fourier transform, in order to establish a testbed and baseline of computation cost.

Then, the candidate will propose an adaptation of [2] to Fourier transform on graphs, implement it and compare it to the baseline. Successful work could lead to a conference paper submission.

3 References

[1] D. Shuman, S. 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(8):83–98, May 2013.

[2] L. Le Magoarou and R. Gribonval, *Learning computationally efficient dictionaries and their implementation as fast transforms*, preprint, `https://hal.inria.fr/hal-01010577`, 2014.

[3] N. Perraudin, J. Paratte, D. Shuman, V. Kalofolias, P. Vandergheynst and D. Hammond, *GSPBOX: A toolbox for signal processing on graphs*, ArXiv e-prints, August 2014. Download toolbox at: `https://lts2research.epfl.ch/gsp/`.