Signal processing and learning over graphs under sparsity

TECHNISCHE UNIVERSITÄT DARMSTADT

Projektseminar/Bachelorthesis/Masterthesis

Network topologies play an important role in many modern network applications including sensor and communication networks, transportation and logistics networks, social media networks, biological networks such as neural networks, gene regulatory networks, and colony networks of bacteria or insects. In contrast to conventional signal processing and data analysis applications that consider, e.g., signals defined over time and/or space, these applications involve data, signals and measurements indexed by graphs, i.e., the data is associated with the nodes or the vertices of a graph.

Recently, novel signal processing techniques emerged under the paradigm of graph signal processing (GSP) that generalize the notion of spectral analysis, band limitation of signals, filtering, sampling, interpolation, and signal reconstruction, i.e. concepts that have originally been defined in time series analysis of classical time signals, to signals defined over graphs. The Graph Fourier Transform (GFT) has emerged as a tool that often admits sparse representations of signals defined over networks. The GFT can be understood as the generalization of the Discrete Fourier Transform to graph signals where instead of the classical Fourier basis that is used in time series analysis the eigenvectors of the adjacency matrix form the orthonormal basis. As the network topology is encoded in the adjacency matrix and the adjacency matrix defines how signal diffuse over the graph, the GFT represents a link between the measurements on the graph and the graph topology.

Under the assumption that the signals are sparse in the GFT domain, which is often the case in applications, sparse dictionary learning approaches can be used to infer the graph topology from network data. In this project, we aim to design novel analysis tools for diverse network applications by combining efforts in sparse optimization, graph learning and graph signal processing.

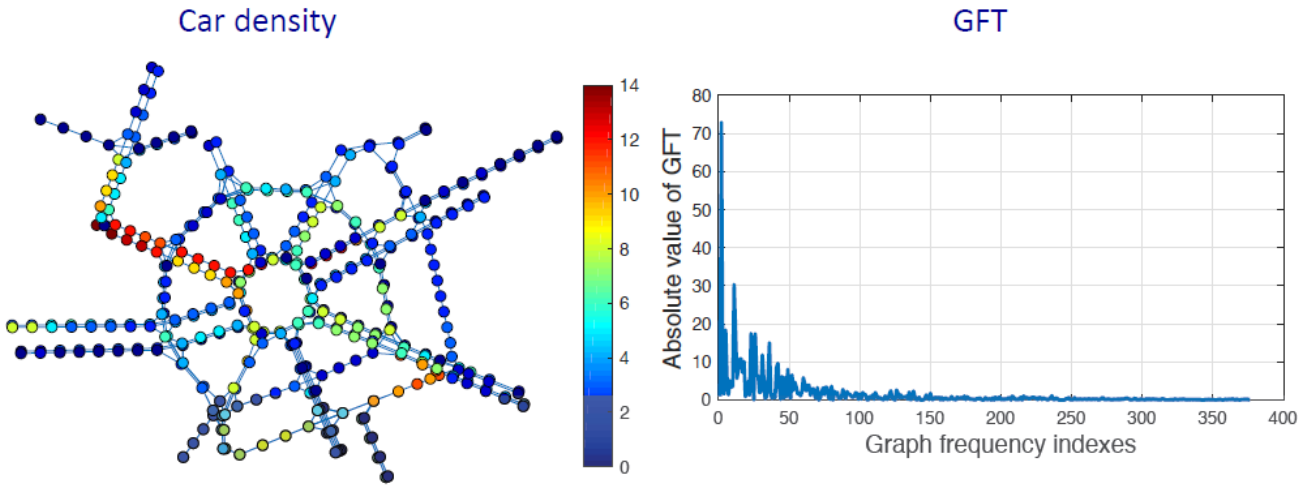

Figure 1: Signal over graph and the graph Fourier transform [1]

Project Phases

- Literature survey on the topic of graph signal processing
- Problem formulation under different assumptions and signal models
- Algorithm development/implementation and performance comparison
- Documentation

Requirement

- Solid knowledge in signal processing
- Strong knowledge in linear algebra and optimization
- MATLAB and/or Python programming

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