Topic Title: Graph Signal Processing

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A. **Problem statement**

Traditional digital signal processing provides techniques for compression, prediction,
filtration, and interpolation. The domain of application is limited to signals on
periodic, directed, discrete domains. This domain can be seen as a directed graph
about a loop. This thesis asks how we may extend these techniques to arbitrary
graphs, such that the domain of application may be extended.

B. **Objective**

The objective of this thesis is to map traditional signal processing theory onto
arbitrary graphs, in order to get the benefits of traditional signal processing like
compression, prediction, filtration, and interpolation on these arbitrary domains.

C. **My solution**

Comparison of graph fourier transforms for parameter-free compression and filtration.
Continuous domain autoregression equations.
Anisotropic distance-correlation fitting of autoregressive equations.
Application of fit to interpolation.
Arbitrary methods for prediction.
Bandpass conditional mutual information for parameterised edge selection.

D. **Contributions** (at most one per line, most important first)

Method to fit anisotropies and multiple diffusion on irregularly sampled systems.
Interpretation of bandpass conditional mutual information for edge selection.
Efficient implementation of algorithm in reference [7].
Comparison of prediction techniques on multivariate temporal data via BIC.
Critique of inverse covariance modelling.
Critique of overuse of BIC leading to Goodhart effects.

E. **Suggestions for future work**

Modelling non-stationary irregularly sampled spatial systems.
Development of cheap proxies for CMI for edge selection on very large graphs.
Application of graph Fourier transforms and filtration to real control processes.

While I may have benefited from discussion with other people, I certify that this report is entirely my own work, except where appropriately documented acknowledgements are included.

Signature:  Date: 22 / 11 / 2025

Pointers

List relevant page numbers in the column on the left. Be precise and selective: Don't list all pages of your report!

7	Problem Statement
7	Objective

Theory (up to 5 most relevant ideas)

15-17	Continuous-domain spatial stochastic processes.
24	Conditional mutual information.
31-33	Spatial autoregressive processes.
38-41	Extending the Matern kernel to deal with anisotropies and negative correlations.
10-12	Graph products and fast GFTs

Method of solution (up to 5 most relevant points)

38-42	Anisotropic distance-correlation fitting of autoregressive equations.
47-48	BIC model selection.
42-44	Comparison of graph wiener filters.

Contributions (most important first)

38-42	Method to fit correlation on irregularly sampled systems.
62-66	Interpretation of bandpass CMI for edge selection.
26	Efficient implementation of algorithm in reference [7].
48-55	Prediction comparison on multivariate temporal data via BIC.
72-75	Critique of inverse covariance modelling.
58-59	Critique of overuse of BIC leading to Goodhart effects.

My work

32-35,40	System block diagrams/algorithms/equations solved
47-48	Description of assessment criteria used
43,51,53, 60	Description of procedure (e.g. for experiments)

Results

36,42,47,65	Succinct presentation of results
45-46,65,72-75	Analysis
72-75	Significance of results

Conclusion

77	Statement of whether the outcomes met the objectives
76	Suggestions for future research

Literature: (up to 5 most important references)

10-12	[18] Moura J., Sandryhaila A. 2014.
16	[38] Whittle P. 1963.
17	[14] Krige D. 1951.
24-25	[12] I. Gel'fand and A. Yaglom, 1959