DEEP LEARNING FOR THE NONLINEAR FILTERING PROBLEM

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1. Project description

The filtering problem concerns finding the conditional distribution of an unknown state, given noisy observations. In applications such as, e.g., signal processing, forecasting and target tracking, it is often a crucial yet difficult objective to solve. The field of nonlinear filtering is a research field within Bayesian statistics that has a lot of connections to Partial Differential Equations (PDE), Stochastic Differential Equations (SDE), Stochastic Partial Differential Equations (SPDE), and Backward Stochastic Differential Equations (BSDE).

In recent years there have been multiple approaches based on deep learning that have set out to achieve scalable methods suitable for (S)PDEs. In the years two of these methods, deep splitting and deep BSDE, have been extended to nonlinear filtering in [1, 2]. The goal of this project is to develop and investigate numerical methods, based on further extensions and new angles, for the nonlinear filtering problem.

1.1. **The suitable student.** In this project it is necessary to have studied at least one course in stochastic analysis. Some familiarity with Bayesian statistics is expected and practical experience with deep learning is strongly meriting.

1.2. **Project and supervision.** This project includes a literature study and close collaboration with the supervisor(s) to develop, implement and evaluate suitable algorithms for the problem. There are multiple angles and directions for this project to take, which can and will be adapted to the student. This include but are not limited to experimenting with different neural network architectures, normalizing methods, numerical analysis, stochastic analysis, and different applications. If you are interested or want to know more, feel free to me and I will get back to you shortly. You can also look at a recent master thesis supervised by me at A Deep Learning Method for Nonlinear Stochastic Filtering.

References

[1] K. Bågmark, A. Andersson, and S. Larsson. Nonlinear filtering based on density approximation and deep BSDE prediction. *arXiv:2508.10630*, 2025.

[2] K. Bågmark, A. Andersson, S. Larsson, and F. Rydin. A convergent scheme for the Bayesian filtering problem based on the Fokker–Planck equation and deep splitting. *arXiv:2409.14585*, 2024.

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