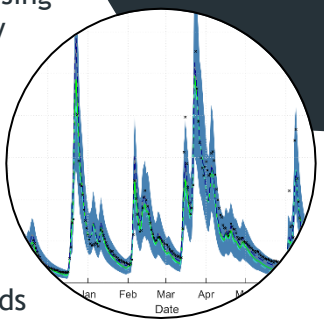
Universität Stuttgart

Cluster of Excellence SimTech
Stuttgart Center for Simulation Science

Interpretable recurrent neural networks for hydrological modeling

M.Sc. Topic

Machine learning (ML) methods are recently gaining popularity in hydrological modeling for discharge prediction, flood estimation and water resources management. Especially long short-term memory (LSTM) networks are suitable to predict timeseries of discharge with some system-specific memory [e.g., 1]. ML methods exploit the increasing databasis of observations and learn functional relationships purely from data, as opposed to traditional conceptual or physics-based hydrological models that rely on physical laws and expert knowledge (e.g., closure of mass balance) and typically suffer from structural errors.



One of the limitations of machine learning approaches for hydrological modeling is their black-box nature: It is hard to decipher their internal functioning, which impedes scientific advances. Methods exist to make recurrent neural networks more interpretable *after* model setup and training. Here, we suggest a more elegant alternative: why not build the network in a way that *a priori* allows for better interpretability?

The goal of this M.Sc. thesis project is to transfer the method of state-regularized recurrent neural networks [2] to hydrological applications. The research question is how the interpretability of the trained network improves over standard LSTM approaches. Expected benefits are (1) new insights into the power of data-driven hydrological modeling, (2) increased system understanding, and (3) better public acceptance of data-driven modeling through credibility and plausiblity.

Tasks

The successful applicant will adapt and extend the existing state-regularized RNN code (MATLAB (?)) to meet the specific needs of hydrological modeling. The proposed method shall be implemented and tested on the Upper Neckar catchment in Southwest Germany. Different previous LSTM versions are available as a starting point; a Python lybrary to train neural networks for hydrological applications [3] can provide further guidance. A conceptual hydrological model for this catchment is available for diagnostic comparison. There is a good possibility of writing and publishing a paper if insightful conclusions are obtained. This project is a collaboration between the Junior Research Group for Statistical Model-Data Integration and the Machine Learning and Simulation Science group, both embedded into the SimTech Cluster of Excellence.

Tasks

- Literature research on LSTMs, interpretability of machine learning, and state regularization
- Implementation of the RNN approach described above
- Evaluation of the implemented method on a case study
- Writing the thesis and presentation at a colloquium

Advisors/Examiners

- Dr. Anneli Guthke (Jun. Research Group Leader for Statistical Model-Data Integration, SimTech)
- Prof. Mathias Niepert (Head of the Machine Learning and Simulation Science Group, SimTech)

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Desireable Skills

- Experience with coding in MATLAB, Python or R
- Knowledge of hydrology, statistics, and/or machine learning

Literature/ Resources

[1] F. Kratzert, D. Klotz, C. Brenner, K. Schulz, and M. Herrnegger. Rainfall–runoff modelling using long short-term memory (LSTM) networks. Hydrology and Earth System Sciences, 22(11), 2018.
[2] C. Wang, and M. Niepert. State-regularized recurrent neural networks. In International Conference on Machine Learning (pp. 6596-6606), 2019.
[3] https://neuralhydrology.github.io/library/

Apply now! Send an e-mail to:
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