

# Model-based Deep Learning with Applications in Wireless Networks



TECHNISCHE  
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## Proposal for a Project Seminar + Bachelor's Thesis | Master's Thesis

Topics: Optimization, Machine Learning, Communication Networks

## Description

In wireless networks, tasks such as resource allocation and estimation often require solving optimization problems. High performance solutions often tend to involve costly algorithms. Deep learning [1] proved successful in several domains such as computer vision to handle extremely difficult problems efficiently. However, research on deep learning was slow in signal processing due to concerns about its explainability and robustness.

Recently, the topic of model-based deep learning and algorithm unrolling gained traction in the signal processing community [2], [3]. The idea is to start from either a classical algorithm or mathematical model, then augment it to allow learning through data. Research shows that this method can produce performant deep networks which are both efficient with respect to training data and adapt well in case of shifting domains [4].

In this thesis, you will investigate model-based deep learning in the context of signal processing in cellular networks. The goal is to develop novel robust deep network architectures that outperform their classical counterparts. Potential applications can be in anomaly detection within communication networks or resilient resource allocation strategies, depending on your interest.

A potential candidate should have familiarity with some of the following topics:

- Signal processing and wireless communication systems.
- Optimization, linear Algebra.
- Machine learning.
- Python (ideally NumPy and PyTorch).

Please contact Lukas Schynol (lschynol@nt.tu-darmstadt.de) if you are interested.

## References

- [1] I. Goodfellow, Y. Bengio, and A. Courville, *Deep Learning* (Adaptive Computation and Machine Learning). Cambridge, Massachusetts: The MIT Press, 2016, 775 pp., ISBN: 978-0-262-03561-3.
- [2] V. Monga and others., "Algorithm Unrolling: Interpretable, Efficient Deep Learning for Signal and Image Processing," *arXiv:1912.10557 [cs, eess]*, 2020. arXiv: 1912.10557 [cs, eess].
- [3] N. Shlezinger, J. Whang, Y. C. Eldar, and A. G. Dimakis, *Model-Based Deep Learning*, 2022. arXiv: 2012.08405 [cs, eess]. [Online]. Available: <http://arxiv.org/abs/2012.08405>.
- [4] L. Schynol and M. Pesavento, "Deep Unfolding in Multicell MU-MIMO," in *2022 30th European Signal Processing Conference (EUSIPCO)*, Belgrade, Serbia: IEEE, 2022, pp. 1631–1635. doi: 10.23919/EUSIPCO55093.2022.9909892.

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