

# Realization of model driven machine learning methods

Attila Miklós Ámon  
ELTE IK

Machine learning enables the solution of many signal processing tasks. Such approaches are particularly advantageous when the input signals are non-stationary or when solving the task requires modeling nonlinear operators. However, the application of machine learning methods faces challenges in various fields (e.g., biological signal processing, autonomous vehicle control, control of critical infrastructure, fault detection). One important reason for this is that models created using machine learning (especially through neural networks) are generally described by parameters that are difficult for humans to interpret. Another problem is that such models typically involve millions of parameters, making their application computationally expensive.

Model-driven machine learning methods offer an interpretable alternative (explainable artificial intelligence (XAI)) to purely data-driven algorithms. In these procedures, machine learning methods are supplemented with classical mathematical transformations. Since the parameters of these transformations typically have specific physical meanings, the resulting models provide a more interpretable structure. Additionally, the introduction of well-chosen transformations simplifies the model's construction, enabling real-time application of the methods.

During my doctoral research, I develop model-driven learning algorithms by integrating various mathematical transformations and artificial intelligence methods (e.g., combining wavelet transformation with neural networks). The developed algorithms serve to solve specific engineering tasks (e.g., detection of railway tracks) and biological signal processing tasks (e.g., ECG, EEG signals). An important aspect of the research is the examination of the practical applicability of the results. The implemented methods should meet the requirements encountered in practice, such as interpretability of parameters and real-time applicability. It is also important that the proposed algorithms and mathematical models do not require expensive target hardware (e.g., GPU) for real-time implementation. This reduces the financial costs of applying the developed procedures and enables the use of hardware with lower energy consumption and less harmful effects on the environment (e.g., microcontrollers, FPGAs) for solving machine learning tasks.