On data driven system identification with artificial neural networks

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Introduction

Artificial Neural Networks (ANNs) are currently used as a methodology that given an appropriate amount of training data, can approximate solutions for complex tasks. For instance, (deep) neural networks can be used for parameter estimation, comparable to other concepts in this field, referring for instance to Kalman-filtering, Markov Chain Monte Carlo (MCMC) or Gauss-Newton methods.

A non-homogeneous system of coupled ordinary differential equations (ODEs) can be used in order to describe the dynamical behaviour of a mechanical system. The choice of initial values can be neglected using a time varying non-homogeneous component.

Artificial Neural Networks, given sequential data derived from the system as input, can serve as parameter estimators ([1], [2]) to partially identify the underlying system matrix. Therefore, the network's parameters can be optimized, using limited variations of the non-homogeneous terms and the system's parameters in the data structure. The neural network then generalizes with high accuracy for validation data, which is based on non-homogeneous terms not being considered during the training phase.

We will discuss, how to derive a dynamical model, that is described as a non-homogeneous system following physical laws. Then artificial sequential data can be computed by (numerically) solving the underlying differential equations of the model for different realizations of the system's parameters. Further we assume that the parameters are in general unknown, and we can only observe the previously computed data. Then a neural network and a dynamical system can be connected in a meaningful way ([3]) to properly make predictions, depending on the given input data ([4]). In this context, we will show that neural networks combined with partial knowledge about the dynamical system's structure can be used to predict the system's parameters for variations of the non-homogeneous terms. This holds for the experienced training data, as well as for the unknown test data.

References

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