Solving partial differential equations using physics informed cascade neural network

Seyedalborz Manavi*[1], Ehsan Fattahi[2] and Thomas Becker[3]

Chair of brewing and beverage technology, Technical University of Munich, 85354 Freising, Germany,
[1]alborz.manavi@tum.de
[2]ehsan.fattahi@tum.de
[3]tb@tum.de

Key Words: *surrogate model, hard constraints, conduction heat transfer, mesh free methods.*

The behavior of many physical phenomena such as fluid flow, wave propagation, elasticity, condensation can be translated into the mathematical formulations by means of partial differential equations (PDEs). Over the past centuries, there has been an ever-increasing demand to efficient and accurate solution of these equations. Recently, deep learning has appeared as a novel method adopted across plenty of applications in the field of computational mechanics for learning the dynamical system models from data. Physics informed neural network (PINN) [1] propose a new paradigm for solving partial differential equations and data driven discovery of partial differential equations. Solving PDEs using neural networks with hard constraints includes an ansatz that comprise different terms, functions satisfying the values on the boundaries, distance values to the boundaries and a deep neural network. In this study our aim is to implement a cascade structure in the ansatz models inspired by idea of cascade forward neural network [2] and compare its performance against conventional method in literature [3]. In this way, the values of boundary function after some iterations (epochs) is replaced with the model estimation in a repeated fashion. Our preliminary results showed that the implementation of this new algorithms led to faster convergence while the same accuracy has been obtained. We are going to study the performance of this algorithm on PDEs such as conduction heat transfer in 1D and 2D problems in details considering different number of updating steps.

References

[1] M. Raissi, P. Perdikaris, G.E. Karniadakis, Physics-informed neural networks: A deep learning framework for solving forward and inverse problems involving nonlinear partial differential equations, Journal of Computational Physics 378 (2019) 686–707.
[2] B. Warsito, R. Santoso, Suparti, H. Yasin, Cascade Forward Neural Network for Time Series Prediction, J. Phys.: Conf. Ser. 1025 (2018) 12097.
[3] J. Berg, K. Nyström, A unified deep artificial neural network approach to partial differential equations in complex geometries, Neurocomputing 317 (2018) 28–41.