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MATHEMATICAL MODELLING IN THE AGE OF DEEP LEARNING

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EKATERINA MURAVLEVA*, IVAN OSELEDETS*

Skolkovo Institute of Science and Technology
143025 Nobel St. 3 Moscow, Russia
I.oseledets@skoltech.ru e.muravleva@skoltech.ru

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ABSTRACT

Recent advances in machine and deep learning led to better-than-human performance in different cognitive tasks such as image recognition, neural machine translation and audio processing. Thus, there is an enormous interest to extend the methods and technologies of deep learning to the area of modeling of complex systems. There are many ways how neural networks can be applied to these tasks. One option is to try to learn directly the mapping between input parameters to the output results, by learning from results of an expensive numerical simulator [1]. Another are where deep learning can be useful is the area of optimization of numerical methods. Modern frameworks, such as Tensorflow and Pytorch are not deep learning frameworks: they are frameworks for differentiable programming: if a function is implemented, we can compute its gradients using automatic differentiation approaches with small overhead, making possible optimization of the parameters of the algorithm. Every algorithm for modeling can be considered as a differentiable program, and thus optimization of the solvers parameters can be done by using machine learning [2]. A much more challenging case is when we only observe time series (trajectories) and we want to learn a model that will be able to predict these trajectories. This is a holy grail of mathematical modeling — how to select a model for a complex system, given only observation. A notable research direction is the idea of using Koopman operators (see for example, recent book [3]). In our minisimposium we will try to bring people working on using and adapting tools from machine learning to mathematical modelling, including supervised and unsupervised (generative) modelling.

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