University of Stuttgart
Germany

Department for Stochastic Simulation
and Safety Research for Hydrosystems (IWS)

Correlation of Weights in Convolutional Neural Network for Heterogeneous System Modelling

M.Sc. Topic

Convolutional Neural Network (CNN) is a neural network architecture usually used in image processing to learn the local convolution-type filters that compress pictures to main features. Thus, the convolutional layers in CNNs have identical weights for neurons across all spatial locations. For physical systems modelling, the translational invariance of CNNs is very useful to represent spatially discretized differential operators by their translation-invariant numerical stencils per control volume (e.g. like in the Finite Volume method).

In spatially heterogeneous physical systems, however, we will need a modification of the CNN structure: while the differential operators are still translation invariant, coefficients are spatially variable (yet typically spatially correlated). The latter requires spatially correlated weights for all neurons that represent the values and actions of spatially variable physical properties.

In this Master's thesis, we want to construct and apply this new modified form of CNN for spatially heterogeneous system modelling by defining a covariance matrix that regulates the spatial correlation of properties. This either leads to a regularization term during classical training, or we will use a Bayesian Neural Network approach to replace training by Bayesian inference/sampling.

Prospective Tasks

- Literature review of state-of-the-art ANNs, CNNs and Bayesian methods
- Design a modified CNN structure to handle correlated weights instead of identical kernel weights
- Train or sample the neural network and analyze the results

General Information

- Advisors: Timothy Praditia, Sebastian Reuschen, apl. Prof. Dr.-Ing. Sergey Oladyshkin, Prof. Dr.-Ing. Wolfgang Nowak

Desirable skills

- Good knowledge on ANNs, mathematics and Bayesian statistics
- Affinity to numerical simulations and programming (Python / Julia)

Apply now!

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