Comparison Of Different Surrogate Models For A Thermoelectric Energy Harvester

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Abstract

For many years now, numerical simulations allow to calculate and predict processes in many fields such as natural sciences, engineering, and economics. To do this, models of the system under consideration are created and animated using equations based on first principles of physics, e.g. conservation laws. This usually leads to the formulation of partial differential equations. Solving these for relevant system sizes / degrees of freedom often takes between a few minutes and a few days. To avoid this problem, substitute models, known as surrogates, can be employed. They are simply formulated mathematical models which can replicate the original model but with one advantage: Once trained, surrogate models need much less time for predictions with comparable accuracy.
As a test case, a thermoelectric generator with a heat sink was simulated in COMSOL. Being parameterized, more than 15 input parameters and 6 quantities of interest are defined within the model. Physically, it combines Heat Transfer in Fluids and Solids and Electric Currents and serves as the source for the required training data. Subsequently, three surrogate models were selected, trained with the same data and their performance was compared. The methods are a deep neural network (DNN), polynomial chaos expansion (PCE), and Gaussian process regression (GPR). The focus is on the accuracy as a function of the training data size.

Figures used in the abstract

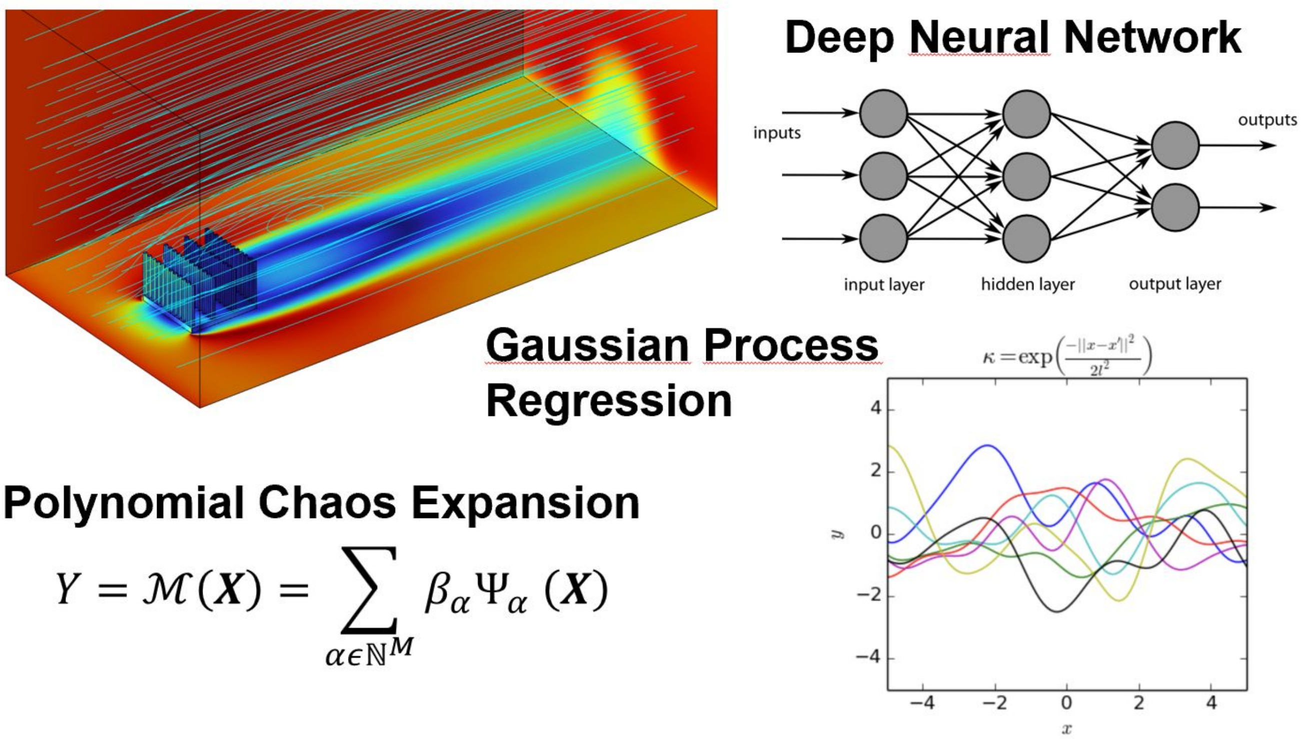

Figure 1 : Data from a multiphysically simulated thermoelectric energy harvester is used to create three different surrogate models.