Technische Universität München

E R A

Ingenieursfakultät Bau Geo Umwelt
Engineering Risk Analysis Group
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Master's thesis proposal

Adaptive learning of artificial neural networks for system reliability analysis

Motivation

Modern society heavily depends on the functionality of lifeline networks such as utility distribution networks and transportation networks, and therefore, it is crucial to make an accurate evaluation of their reliability. While the operation of these networks can be effectively represented using graphs (i.e., a mathematical entity consisting of nodes and edges), graph algorithms may require high computational cost as a network size increases. As a result, the reliability analysis of large-scale systems remains challenging.

Such size issue can be addressed by surrogate models, which, by being trained with a limited number of data in advance, can make instant predictions. To this purpose, artificial neural networks (ANNs) have shown a powerful performance and been widely applied to replace expensive system analysis such as graph algorithms or structural dynamics. However, to secure a prediction accuracy, ANNs should be provided with a training dataset that effectively represents the input space of interest. This remains challenging for system reliability analysis, which is characterized by the high dimensionality of input variables.

Methods

To address the challenges, the proposed MSc project will…

- adopt the state-of-the-art learning functions for probabilistic ANNs.
- train ANNs to predict the performance of lifeline networks that are represented as graphs.
- combine ANNs' probabilistic prediction and Monte Carlo Simulation (MCS) to estimate a network's reliability.

Expectations

- Basic knowledge of probabilistic/statistics theory
- Basic knowledge of programming (first preference is Python and second is Matlab)

Suggested workflow

The student will…

- review the literature on adaptive learning of surrogate models and representative topologies of lifeline networks.
- train ANNs to predict networks' performance while adaptively generating training datasets.
- apply trained ANNs and sampling methods to estimate networks' reliability and quantify uncertainties arising respectively from problem construction and prediction errors by ANNs.
- provide comments/suggestions on the choice of learning functions, the construction of ANNs to predict network performance, and the impact of ANNs' prediction errors on the accuracy of reliability analysis.

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