Real-Time Prediction of Structural Processes with Polymorphic Uncertain Data

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Abstract

Numerical simulation methods used to predict the system behavior of geotechnical interventions, need to account for the polymorphic uncertainty of the underlying geotechnical data. This paper is concerned with numerical reliability analysis in mechanized tunneling. Recently, in Freitag et al. (2015), a reliability model was presented, taking uncertain geotechnical data by means of stochastic numbers, intervals and interval stochastic numbers into account. The numerical simulations are performed with a hybrid surrogate model (i.e. a combination of Proper Orthogonal Decomposition and Artificial Neural Network approaches), which is generated based on results of a process oriented 3D finite element model for shield tunneling taking into account all relevant components of the construction process, see Meschke et al. (2013). The polymorphic uncertain input data are processed by combining Monte Carlo simulation and interval analysis. For the purpose of the interval analysis, a deterministic input-output surrogate model is employed together with an optimization approach (Particle Swarm Optimization) to predict interval surface settlements fields during the tunnel construction process. However, the computation time for the optimization procedure of a large number of outputs (i.e. settlements at all surface points) is increasing dramatically and may be inappropriate for real-time simulations to support the tunnel boring machine steering. In this paper, a surrogate modeling strategy for interval input-output data is introduced, which is capable of predicting high dimensional interval fields of surface settlements in real-time. The approach focuses on splitting interval data into midpoint and radius representation and predicting them separately with the surrogate model. The available monitoring data of the settlement field is also integrated into the surrogate model with the aim to reduce the predicted interval uncertainty. The new method is applied for reliability analyses with polymorphic uncertain data (p-boxes, fuzzy stochastic numbers, fuzzy numbers, intervals) in mechanized tunneling.

References

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