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BAYESION OPTIMAL EXPERIMENTAL DESIGN FOR PARAMETER IDENTIFICATION IN MECHANISED TUNNELLING

Raoul Hoelter

Ruhr-University Bochum, Germany
raoul.hoelter@rub.de

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Abstract: Modern demands for safe and efficient infrastructure in urban areas make the construction of tunnels unavoidable. However, tunnel construction is facing challenges due to complex ground conditions and small depths of cover. Therefore, a finite-element- model based simulation of the system behaviour is helpful to predict settlements induced by the construction what enables to perform suitable countermeasures. Such simulation models needsto be validated with in-situ data. Besides soil sampling, that allows a preliminary design of the ground conditions, it is helpful to install sensors that will record the tunneling induced system response and to use this data for a back analysis of the system parameters. Two issues have to receive sufficient attention in such a case namely (i) how to use measurement data of an ongoing tunnel excavation to predict the system response in the forthcoming cross sections in the same tunnel line; and (ii) how to design the measurement system in a matter that it optimally allows to identify the relevant soil parameters. To address both aspects, the present works applies the method of Bayesian Optimal Experimental Design (Bayesian OED) to a synthetic Finite-Element model that simulates the construction of a shallow tunnel nearby a surface structure. In the framework of a probabilistic scenario, the soil parameters are assumed to be initially known as probability distributions. To identify their real values, synthetic noisy settlement data is generated in positions that are defined according to the principles of OED, i.e. in a way that allows to identify the relevant parameters with least possible uncertainty. As the tunnel excavation proceeds gradually, after each excavation step a new situation (stress state, deformations, etc.) is faced. The obtained data is used to update the knowledge about the parameters according to the principle of Bayes' theorem. Using this updated model and considering the next excavation step which is about to take place, the initially defined OED is most likely to be not optimal anymore. Therefore, a new design of the measurement set-up is needed that is defined again using the Bayesian approach: Considering the current knowledge of the system, which measurement set-up will allow in the next step most reduction of uncertainty after performing a parameter identification? This procedure is continuously repeated, as long as the tunnel excavation is taking place in areas that may have a critical impact on nearby infrastructure. Thereby, the parameters can be identified most precisely and efficiently.