Application of Substructuring and Resampling for Estimating Sobol' Indices

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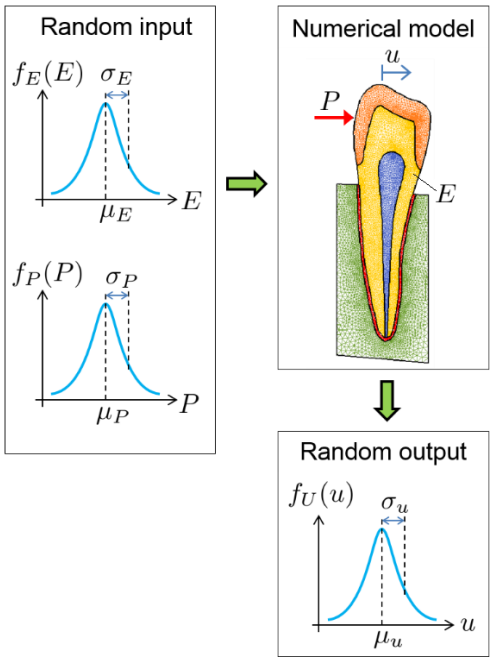
Recent developments in computational mechanics allow constructing detailed numerical models for predicting the response of structural systems. A key issue for a proper definition of a model is identifying its input parameters, as there is inherent uncertainty associated with the values of loads, material properties, etc. This uncertainty can be accounted for through probability theory. Thus, input parameters are characterized as random variables. In turn, the output of the numerical model becomes random as well. Hence, the application of appropriate methods such as Monte Carlo simulation allow propagating the uncertainty from the input variables to the output, quantifying the effects of uncertainty on the structural response in terms of, e.g. second order statistics, probabilities of exceedance, etc.



Additionally, a *sensitivity analysis* can provide much insight on the behavior of a model, pinpointing its most influential input parameters. Such type of information is crucial for, e.g. risk analysis and decision making. One approach for performing sensitivity analysis is applying variance-based measures, such as Sobol' indices. These indices provide information on the fraction of the variance of the output response that can be attributed to a particular random input variable or a group of input variables. For cases of practical interest, the estimation of these indices must be performed via Monte Carlo simulation. This is numerically demanding, as it comprises hundreds of thousands or even millions of samples. In view of this issue, this contribution presents an approach for calculating Sobol' indices most efficiently. The approach is based on two concepts: *substructuring* and *resampling*. Substructuring is applied for creating a *database* of precomputed solutions for portions of the structure. Then, these precomputed solutions are resampled, producing a large number of samples of the structural response, but at a fraction of the cost associated with a full structural analysis. This is due to the fact that the substructures have already been analyzed separately (i.e. precomputed); therefore, a structural analysis at the interface level suffices for calculating the structural response. In this way, it is possible to estimate the sought indices with high numerical efficiency. The application of the proposed scheme is illustrated by performing a sensitivity analysis of a finite element model of a human tooth subject to static loading.

About the Speaker

Marcos Valdebenito obtained his doctoral degree at the University of Innsbruck, Austria, under the supervision of Professor G.I. Schuëller. In 2010, he joined the Department of Civil Engineering of Santa Maria University, Valparaíso, Chile, where he is currently an assistant professor. In 2016, he received the K.J. Bathe Award for the best paper published in Computers & Structures in the years 2014 and 2015 by an author below the age of 40. His main research interest is the development of strategies for uncertainty quantification in computational mechanics. Within this broad field, his particular research interests are reliability assessment by means of advanced simulation methods, stochastic finite elements, reliability-based optimization and fuzzy analysis.