Recent developments of parameter identification/inverse analysis in civil engineering

Takayuki SHUKU
Okayama University, Japan

Much research in science and engineering is devoted to developing numerical models of physical systems. The numerical models allow us to predict the response of physical systems. This prediction is called forward or direct problem. The inverse problem is inferring the values of the model parameters and characteristics of the systems using measurement of the system response.

While forward problem generally has a unique solution, the inverse problem does not. In most inverse problem, solution is not unique (it has multiple solutions) or solution does not even exist. This kind of inverse problem is called “ill-posed (ill-conditioned)” problem and difficult to solve. Recent developments of performance of computers and mathematical algorithms, however, allow us to deal with the difficulty.

This presentation covers two recent topics of parameter identification/inverse analysis in civil engineering.

The first topic is about the statistical parameter identification method called particle filter (PF). The PF is one of the Monte Carlo methodologies for estimating probability density functions of parameters and characteristics of systems. The biggest advantages of the PF include its simple implementation and applicability to nonlinear and non-Gaussian problems. The performance of the PF is demonstrated by showing two application examples: identification of geotechnical parameters in FEM/DEM simulations and probability estimation for structural parameters.

The second topic is about sparse modeling. Many methodologies for managing ill-posedness in inverse problems have been proposed. The sparse modeling, which essentially favors simple theories over more complex ones, is central to many research fields and is believed to have been inspired by an early doctrine formulated by the 14th-century philosopher and theologian William of Ockham. In particular, sparse modeling has received much attention recently in image and vision processing as well as machine learning. According to the general principle of sparsity, a phenomenon should be represented with as few variables as possible.

In this presentation, a sparse modeling-based geophysical tomography method and its effectiveness are presented by showing a numerical example of cross-hole seismic tomography: an image of the spatial distribution of the geotechnical parameters of the ground is reconstructed using the proposed method, and the results are compared with those of a current method.

Key words: inverse analysis, particle filter, sparse modeling