

Neural Networks: New Results and Prospects of Applications in Structural Engineering

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ABSTRACT

NN is a new computational tool for data processing and this tool can be characterized as a "data dependent and model free" approach. Other features of NNs correspond to their applicability in the analysis of nonlinear direct and inverse problems. NNs can also be used in hybrid systems as a complementary part to conventional computational methods, especially to FEM.

The applications of the feed-forward, multilayer, error back-propagation NN, called for short BPNN (back-propagation NN), are discussed focusing on two fields: 1) BPNN as a new independent computational tool, 2) hybrid FEM/BPNN systems. All the considered applications are based on data taken from tests on laboratory models or measurements performed on natural scale buildings. BPNN applications are illustrated on four selected problems.

The first one is related to soil-structure interaction caused by paraseismic excitations. The mappings of displacement response spectra DRSg $\rightarrow$ DRSb were performed, where: DRSg – spectrum computed on the ground level at a monitored building, DRSb – neurally predicted spectrum inside the building on the basement level. It was proved that the application of Kalman filtering for the training of a BPNN leads to much more exact approximation than the application of Rprop learning method.

The second problem is related to the identification of placement of an additional mass fastened to a steel plate. The dynamic response corresponding to natural eigenfrequencies of the plate with the mass was used as the BPNN input. Satisfactory results for the parametric identification of the mass location were obtained due to addition of the Gaussian white noise to perturb a small number of measured dynamic responses and due to the application of cascade architecture of BPNNs.

The third problem deals with the application of hybrid FEM/BPNN Monte Carlo method in the reliability analysis of steel cylindrical panels. The results of laboratory tests were explored to update the FE model which was then used to compute the patterns for the BPNN training and testing. The trained network was explored to rapid computation of Monte Carlo simulations of the panel ultimate load. It was shown that the hybrid approach enables us to predict the probability of reliable curve very efficiently.

The fourth problem is related to the hybrid approach of the FE model updating. It is discussed on the example of a simple plane frame tested on laboratory models. In the formulated hybrid system a FE program was used for generating the training and testing sets of patterns. The trained BPNN was then explored in the inverse analysis for calibrating of control parameters values which well corresponded to the measured eigenfrequencies of the frame laboratory models. Using BPNNs in the hybrid updating of FE models makes it possible to eliminate the optimization procedure in the corresponding inverse analysis.