Chapter XV

Application of Neurocomputing to Parametric Identification Using Dynamic Responses

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Abstract

The chapter focuses on the applications of neurocomputing to the analysis of identification problems in structural dynamics, the main attention is paid to back-propagation neural networks. The analysed problems relate to (a) application of dynamic response to parameter identification of structural elements with defects modelled as a local change of stiffness or material loss; (b) updating of FEM models of beams, including the identification of material parameters and parameters describing possible defect; (c) identification of circular void or supplementary mass in vibrating plates; (d) identification of a damage in frame structures using both eigenfrequencies and elements of eigenvectors as input data. In the examples involving the experimental measurements the application of a random noise to increase the not sufficient number of data is proposed. The presented results have proved the proposed method capable of carrying out the appointed task and indicated good prospects of neurocomputing application to dynamics of structures.

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Artificial neural networks (ANNs) have features associated with their biological origin (Haykin, 1999). They are massively parallel and can process not only crisp but also noisy and incomplete data. Moreover, ANNs can be used for both approximation and classification purposes (Paez, 1993). Thanks to their generalization features they can be applied to the analysis of problems which obey certain rules learned by the networks during the training process. Such features enable us to apply ANNs in both direct and inverse analysis. ANNs advantages offer, in fact, complementary possibilities to standard computational methods, finite element method (FEM) in particular.

Computer simulations of artificial neural networks, called for short neurocomputing, can be used efficiently in the analysis of various problems of structural engineering. This concerns especially a standard feedforward neural network called in literature “multilayer perceptron” or “back-propagation neural network” (BPNN). BPNN is used for mapping of its inputs into outputs without an a priori assumed format of the approximated relations. This ability of BPNNs opens the door for implicit modelling of structural relations. Another possibility is associated with formulation of outputs as identified structural or material parameters, which corresponds to identification of structural systems (inverse analysis). For detailed explanation of neural networks basics, see Chapter XVI in this book. Following the topics of the chapter, the main attention will be focused on the applications of neurocomputing to the analysis of identification problems (inverse problems). For such purposes, NNs can be used either as an independent tool or they can interact with standard computational methods.

Different types of ANNs can be used in the inverse analysis of structural mechanics problems. The majority of engineering applications is related to taking advantage of the multilayer perceptron. The main part of the chapter is focused on ANNs applications to the identification problems of structural engineering.

The authors’ attention is focused on parameter identification related to the so-called explicit modelling. It means that certain structural or material characteristics are adopted as functions of unknown parameters, which are to be calibrated during the identification process.

The problems considered above and corresponding tools are discussed on examples of engineering problems with particular attention to structural experimental mechanics.

In the Department of Structural Mechanics of the Rzeszów University of Technology, Poland, different nondestructive methods of materials and structural element testing have been developed. Special attention has been paid to measurements of dynamic responses to impact excitations. After transformation of records from time to spectral domain (fast Fourier transformation (FFT) was used) natural eigenfrequencies can be obtained. The values of eigenfrequencies are functions of unknown parameters corresponding to the analysed problem. If the eigenfrequencies are used as inputs of BPNN the unknown, sought parameters can be obtained as outputs from this NN.

The above sketched approach is discussed with respect to problems of damage parameter identification for simple structures, identification of various parameters (mass, material constant) and updating of dynamic models.

The damage parameter identification was also performed by wave propagation technique, using records from time domain without their transformation to spectral domain. Sets of
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