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NEURAL NETWORKS APPLIED TO DAMAGE EVALUATION IN EXPERIMENTAL TESTS

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ABSTRACT

Development of efficient methodologies to determine the presence, location and severity of damage in structural components is an important task of Structural Health Monitoring (SHM) [1] systems for both aging and new structures. The structure has to be equipped with an array of actuators and sensors (placed at certain locations) in order to excite and record its dynamic responses. Supposing that the measured signals are affected by the presence and severity of damage, the well defined SHM system should provide an approximation of damage parameters.

This paper presents some recent results of Artificial Neural Networks (ANNs) [2] application in the field of the Nondestructive Testing and Evaluation (NDT&E) techniques. In this approach, the ANNs were applied to predict the extent of damage in laboratory models of strip and plate elements. The basic idea of the studied cases utilizes propagation of the elastic waves in solids. Since theirs disturbance due to the damage appearance and growth is rather complex to direct analysis, the authors proposed ANNs combined with advanced signal processing techniques as a tool of faults recognition. The laboratory setup, equipment and schemes of models were shown on the Fig. 1. A detailed description of the SHM system as well as preliminary results may be found in the number of previous papers [3–5].

The Patterns Database for the ANNs training procedure was obtained from the laboratory investigations on various elements. The common problem of such tests, and particularly damage detection, is a relatively small number of patterns we may obtain from a single model. Last but not least is a measurement precision and influence of environmental effects, like temperature, humidity, etc. Nevertheless, the proper ANNs training seems to be still possible, but only when a number of certain conditions is satisfied. Finally, the objective of the research is the ANN that reaches reasonably well level of generalization and avoids the data overfitting [2].

When the training set is small, the obtaining results are strongly influenced by the selection of patterns to both learn and validation sets. Due to this fact, the manual selection (30% of patterns) with uniform distribution was utilized in order to specify the validation set. Robustness of each designed ANN was tested by few dozen repetitions of training procedure and statistical parameters analysis.

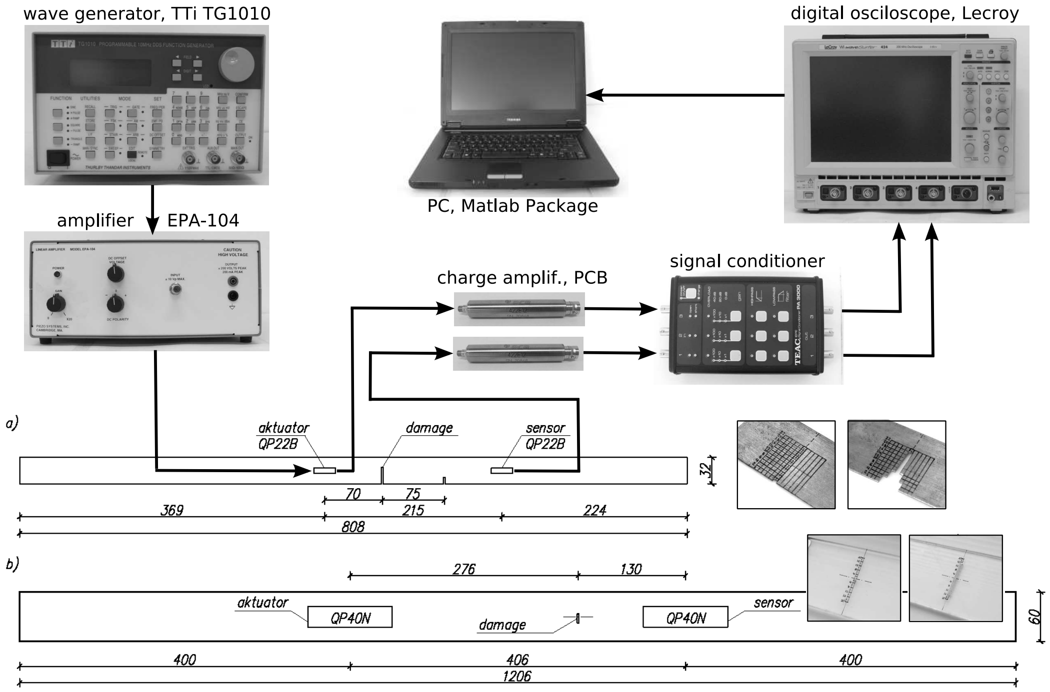

Figure 1: The laboratory setup, equipment and schemes of models.

The performed investigations has proved that for majority of tests, the applied data processing techniques, like e.g. wavelet denosing and digital filtering, have improved the accuracy of predicted damage parameters. Followed several tests, the ANNs architecture was tuned and the simplest networks models (one hidden layer with few neurons) seems to be privileged here. Finally, the designed ANNs were able to predict the damages parameters with precision tolerance even less than 1 mm.

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