# Wavelet Transform and Soft Computing in Damage Identification

**Anna Knitter-Piatkowska[1*], Tomasz Garbowski[1]**

[1]Institute of Structural Engineering
Poznan University of Technology
ul. Piotrowo 5, 60-965 Poznan
anna.knitter-piatkowska@put.poznan.pl
tomasz.garbowski@put.poznan.pl

## ABSTRACT

The problem of damage detection is closely connected with structural health monitoring and safety assessment. Even small and local damage leads to stiffness reduction, increases damping and decreases a natural frequency of the structure, therefore damage detection methods based on analysis of structural dynamic response can be easily applied to identify the presence of a defect.

In this work the attention is focused on Wavelet Transformation in its discrete form (DWT). The most fundamental challenge is the fact that local damage may not significantly influence the global structural response. Signal decomposition using WT allows to detect the damage because it demonstrates strong disturbance in a place of a defect. It follows from the experience [1] that in the class of considered problems the most effective appeared Daubechies wavelet of 4th order with two vanishing moments. However, data processing of the structural response signal using CWT or DWT (e.g. Lipschitz exponent) has appeared to be rather ineffective in identification of the type or shape of a defect. Therefore, herein the usefulness of an alternative method of more precise damage identification i.e. a combination of DWT and inverse analysis is studied.

The inverse analysis provides an important tool if one would like to characterize a bigger number of damage parameters, such as the type or shape. This technique uses, besides the wavelet representations of the experimental measurements, also their numerical counterparts obtained from the computer test simulation. Authors use a parametrized FE model which mimic the real structure subjected to dynamic mechanical excitation. All control parameters gathered in the vector **x** are embedded in the numerical model; by changing them one can minimize the discrepancy between the wavelet representation of both 'real' and numerically computed measurable quantities.

The discrepancy between experimental and numerical measurable quantities (objective function) can be minimize e.g. by making use of iterative minimization gradient based algorithms [2]. Here, for the discrepancy function minimization (within least-square framework) the deterministic, iterative Trust Region Algorithm (TRA) is used. The procedure is divided into two steps: first decomposition of the output structural response signal, e.g. strains, using DWT and second application of TRA to limited search field to the number of elements, where there are wavelet disturbances. In the later stage the global minimization technique such as Genetic Algorithms (GA) are employed. Only the solution provided by application of GA on the output signal represented by wavelet coefficients appeared to be successful. All defect details, such as location, intensity, shape or number, were clearly identified.

### References

[1] A. Knitter-Piatkowska, Z. Pozorski, A. Garstecki, Application of discrete wavelet transformation in damage detection. Part I: Static and dynamic experiments. *Computers Assisted Mechanics and Engineering Sciences*, **13**, 21-38, 2006.

[2] T. Garbowski, G. Maier, G. Novati, Diagnosis of concrete dams by flat-jack tests and inverse analysis based on proper orthogonal decomposition. *Journal of Mechanics of Materials and Structures*, **6**, **1-4**, 181-202, 2011.