Genetic Algorithms in Health Monitoring of Structures

The development of real-time, in-service structural health monitoring and damage detection technique has recently attracted a large number of academic and industrial researchers.

The basic concept of the frequency-based structural health monitoring technique is to monitor the variations in the structural natural frequencies changes caused by the presence of damage. Through monitoring the measured natural frequencies and comparing them to a baseline measurement (for undamaged structure), we can qualitatively determine that structural damage has occurred or is imminent.

The lecture presents results on the identification of damage in composite structures via genetic search technique and changes in natural frequencies. Location and size of the damage are carried out by minimization of an error function involving the difference between calculated and measured natural frequencies. Simulation studies indicate that changes in natural frequencies and genetic algorithm allow to estimate delamination parameters (location and size) very accurate and fast.

Genetic algorithm is a search technique based on ideas from the science of genetics and the process of natural selection. Differences between conventional search techniques and the genetic algorithm (GA) can be summarised as follows:

GA operate on coded form of task parameters,
GA works with a population which represents numerical values of a particular variables,
GA used only objective function,
GA applied only probabilistic rules of selection.

A simple genetic algorithm consists of three basic operations: reproduction, crossover and mutation. The algorithm starts with the randomly generated initial population. The members of this population are usually binary strings (called chromosomes). Particular elements of chromosomes are called genes. In these strings are coded values of a variable or variables, which can be a solution of examining problem in the search space. These variables are then used to evaluate the corresponding fitness value which is the objective function.

Objective function used in the presented examples is based on the changes in natural frequencies from measurements. Changes in natural frequencies may be called the classical damage indicators if any. They are without any doubt the most used damage indicators both formerly and nowadays. The main reason for the great popularity is, that natural frequencies are rather easy to determine with relatively high level of accuracy. In fact, one sensor placed on a structure and connected to a frequency analyser gives estimates for several natural frequencies. Further, natural frequencies are sensible to all kind of damage - local and global damage.

The advantages and limitations of the present technique are also discussed.