Structural Damage Detection in Steel Plates using Artificial Neural Networks

ABSTRACT

The advancements and applications available in the signal processing and pattern classification area help in the early detection of faults and damages with less effort. In the recent past the nondestructive methods employed in damage detection has received more importance. This research work intends to identify the damages present in the steel plates using nondestructive vibration testing. This research work has been divided into three phases. In the first phase, two simple experimental models have been developed to hold the steel plate complying with the boundary conditions (simply supported and fixed free). Suitable piezoelectric accelerometers, impact hammer and the Data Acquisition System (DAQ) are identified to perform the experimental modal analysis. The data capturing protocol is designed to perform the impact testing. The steel plate is divided into cells of area 4 cm^2. The cell locations are sequentially numbered from 1 through 36. The accelerometers and the impact hammer are placed on the four corners of the cell according to the protocol. The accessories are connected to the DAQ and monitored in the software interface. The vibration signals for both the experimental models are recorded in the native DAQ file format and later converted into '.wav' file format for processing. The vibration signals in normal condition of the steel plate are recorded. The damages of size 512 μm to 1852 μm are simulated manually on the steel plate using drill bits. The vibration signals in the fault conditions of the steel plate are collected. In the second phase, the captured vibration signals are preprocessed by applying windowing technique to remove external disturbances. Feature extraction algorithms based on Frame energy analysis,Discrete Cosine Transformation (DCT) and Discrete Fourier Transformation (DFT) are developed to extract features from the vibration signals. The conditions of the steel plate namely healthy and faulty are associated with the extracted features to establish input output mapping. The data are processed to remove outliers and redundancy. The data are then normalized and randomized to rearrange the values into definite range. The principal components in the data are identified using Principal Component Analysis (PCA) to reduce data dimensionality. In the third phase, two simple feedforward neural network models: Multilayer Perceptron (MLP) and Radial Basis Function (RBF) are modeled. The neural network parameters are adjusted to train the network. The neural network models are trained with 60%, 70% and 80% of the total data samples. The trained neural network is validated with 100% data samples by simulating the network. The actual output is compared with the desired output with a thresholding criterion. The performance of the network is calculated by measuring the true positives, false negatives, classification accuracy, sensitivity and specificity are calculated and the results are compared.