Artificial Neural Network-Based System for Location of Structural Faults on Anchor Rods Using Input Impedance Response

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***Abstract*—This paper presents a new system designed to localize the position of structural faults on anchor rods based on a nondestructive technique. The proposed system uses Artificial Neural Networks (ANNs) to learn from data and to create an approximation function, mapping the high-frequency responses of the input impedance parameter into the respective positions of the fault on the rods. Computational models of different patterns of fault were designed in a high-frequency simulator in order to increase the amount of data available to train the ANNs.**

***Index Terms*—Artificial neural networks, computer simulation, fault location, impedance measurement.**

I. Introduction

Anchor rods are important structural elements to support guyed towers of power transmission lines. Faults on these rods caused mainly by corrosion may lead to a collapse of the tower and disruption in the energy delivery. The traditional maintenance is destructive, expensive and hazardous because it involves rod excavation under guyed transmission towers.

In this paper, an extra functionality is added to the fault detection technique proposed in [1]. The new results show that the position of a structural fault on the anchor rods can also be non-invasively determined by an ANN-based system through the processing of input impedance responses.

II. Methodology

A set of 3,047 computational models with several types of fault has been designed in the high-fidelity simulator Ansys HFSS. Such simulations have been validated against 20 sets of actual measurements performed on 10 different real anchor rods and incorporated into a combined database of input impedance (Z_{in}) responses in order to train the ANNs. ANNs were chosen among all available techniques due to their high capacity of modelling complex signals based only on input-output relationships, without the need of physical models.

The real and imaginary parts of the input impedance signals were normalized and their main features extracted through Principal Component Analysis (PCA). Then, the signals were applied into a pair of independent ANNs with 44-121-121-1 and 38-104-104-1 neurons for $Re\{Z_{in}\}$ and $Im\{Z_{in}\}$ signals, respectively. Such configuration was defined after exhaustive experiments. The output of each individual ANN gives the fault position, varying from zero to the total length of the tested rods (1 m). Finally, such outputs are averaged to give an overall estimate of the fault position, as depicted in Fig. 1.

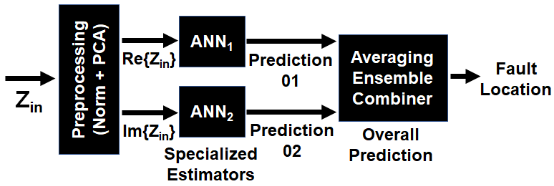
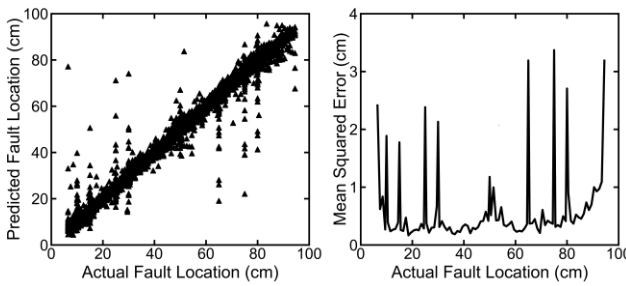


Fig. 1. Basic scheme of the ANN-based fault location system.

III. Results

The performance of the system was evaluated through a 10-fold cross-validation procedure, with 90% of the samples used for training and the remaining 10% for testing on each round. PCA preprocessing reduced the dimensions of the signals to only 5% while preserving 99% of the original variance. The system predictions are exhibited in Fig. 2 (a) and presented a total mean squared error (MSE) of 0.62 cm as shown in Fig. 2 (b). The final model presented 35,410 parameters to be tuned, which is done in about 8 minutes in a computer with a 64 bits 2.90 GHz Processor and 6 MB RAM. The location process, instead, requires less than 3 s to be performed.

It is shown that input impedance signals are able to convey information about the position of the faults on the anchor rods. The proposed pair of independent ANNs associated with PCA preprocessing strategy provides different representations of the input signals to the system. Such approach achieves fast and accurate results while avoids overfitting of the model and requires a low computational effort to run.



(a) (b)

Fig. 2. Performance of the system. (a) Overall predicted fault location. (b) Mean squared error of the predictions in function of the actual fault location.

References

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