Chapter 10
Artificial Neural Networks to Improve Current Harmonics Identification and Compensation

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ABSTRACT

Artificial Neural Networks (ANNs) have demonstrated very interesting properties in adaptive identification schemes and control laws. In this work, they are employed for the on-line control strategy of an Active Power Filter (APF) in order to improve its performance. Indeed, neural-based approaches are synthesized to design adaptive and efficient harmonic identification schemes. The proposed neural approaches are employed for compensating for the changing harmonic distortions introduced in a power distribution system by unknown nonlinear loads. The implementation of the ANNs has been optimized on a digital signal processor for real-time experiments. The feasibility of the implementation has been validated and the neural compensation schemes exhibit good performances compared to conventional approaches. By their learning capabilities, ANNs are able to take into account time-varying parameters such as voltage sags and harmonic content changes, and thus appreciably improve the performance of the APF compared to the one obtained with traditional compensating methods.

INTRODUCTION

Applications of artificial intelligence and adaptive behavior techniques have yielded interesting results according to their considerable flexibility capabilities. The ability to handle problems with time-dependent

DOI: 10.4018/978-1-61520-849-4.ch010

parameters, such as dynamic systems modeling and control, particularly demonstrates the success of connectionism. Indeed, in the past five decades, major advances have been achieved in identifying and controlling linear and nonlinear time-varying plants with unknown parameters using Artificial Neural Networks (ANNs). Well established results (Narendra & Parthasarathy, 1990) have led to stable adaptive identification schemes and control laws. In these cases, the global stability of the relevant overall system is assured based on the properties of the control theory. However, there are no pre-established rules and theories for determining the choice of the neural architecture, the parameters, the learning method, and not even the adaptive control law. The design of efficient neural solutions is not trivial. On the other hand, a good analysis of the problem and an adequate design lead to neural solutions that behave in a desired fashion, i.e., that "learn from examples" for modeling a system.

A fundamental aspect of ANNs is the use of simple processing elements which are essentially models of neurons. A neuron is a basic node element taking several inputs which can be data or signals from the real world or from other network nodes. The output is a function of the summed weighted strength inputs. This function represents a threshold action, whether or not the node has fired due to weighted sum exceeding a previously defined threshold value. However, the neuron model can differ in terms of the type of network considered. A neural network consists of a number of simple node elements which are connected together to form a topology. The relative strength between two nodes, i.e., the connections or the weights, are then determined as the network learns a specified task. The learning tries to find out the weight values of the overall network in order to mimic the task as precisely as possible from measured data.

An ANN or a connectionist model is considered as a computing machine or a dynamic system characterized by:

- Parallel architecture; because composed of many parallel interconnected processing elements, i.e., the neurons,
- Similarity of the neurons; because each neurons composing the network is described by a standard nonlinear algebraic equation,
- Adjustable weights; because every single interconnection between two neurons is an adjustable parameters.

A connectionist model therefore creates a function of neurons (processing units) and it may modify its parameters (weights) in the resulting form of approximation by the learning or training procedure.

Once the ANN has been designed and trained, it operates as a model function, outputting the values of a specific function or task. The function thus created is an approximation of the true function or task. ANNs can thus be used as a representation framework for modeling nonlinear dynamical systems and it is also possible to incorporate these nonlinear models within a nonlinear feedback control structure. The ability of ANNs to approximate nonlinear systems is thus of central importance in this task. This has led to efficient neural control laws or neurocontrol as synthesized in different reference works like in (Zbikowski & Hunt, 1996), in (Irwin, Warwick, & Hunt, 1995) and more recently in (Nørgaard, Ravn, Poulsen, & Hansen, 2000).

Two categories of controllers can clearly be considered: Highly specialized and general purpose controllers. The first are relevant when the system to be identified or controlled is difficult to stabilize or when the performance is extremely important. The second ones have structures that can be used on a wide range of practical systems. They are characterized by being simple to tune so that a satisfactory

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