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Chapter 13

An Information System for Monitoring of Power Quality Disturbances

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The paper presents a neural-fuzzy-technique-based classifier for pattern recognition problems with uncertain distributions. Neural networks in the architecture of Frequency Sensitive Competitive Learning and Learning Vector Quantization are first employed to evaluate the decision boundaries separating different patterns to be classified. To deal with the uncertainties of the involved recognition problems, however, the output of the neural networks is used to activate a fuzzy-associative-memory rule-base to accomplish the classification, instead of being taken directly as the final identification. With the Internet and the developed classifiers, an information system can be built up for power quality monitoring over whole power networks.

INTRODUCTION

Historically, purchasing power has been a simple task for end-users. Power was sold on a "take it as it is basis." In the past 10 years, an important facet of electricity has emerged as computers and other electronic equipment have per-

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vaded every aspect of our businesses and homes. Although so far the emphasis related to deregulation is on price, power quality, as the product of electricity unbundles, will become every bit as important as price. It is clear that power quality monitoring, with respect to the recognition of disturbances from each individual site measurement and the effective surveillance to whole power networks, is among the most important research issues in this field (Dugan, McGranghan & Beaty, 1996).

Pattern recognition problems come in many forms. Different problems allow different solution approaches such as the statistical, the syntactic, and the neural pattern recognition approach (Schalkoff, 1992). Due to the lack of statistical and/or structural information in many circumstances, the neural network approach has been widely applied in pattern recognition applications. Among different types of neural networks, the one with the architecture of Learning Vector Quantization (LVQ) has been recognized for its advantages in some applications over its counterparts such as Multi-Layer Perception (MLP) (Antognetti & Milutionovic, 1991; Haykin, 1994).

In spite of the advantages, neural networks may also face a computational dilemma sometimes. On the one hand, for most problems the number of the input-output pairs needed to check may be computationally prohibitive. On the other, all the input-output cases are tractable. It is apparent that the neural networks are unreliable for the former and are unnecessary for the later. In contrast, fuzzy systems directly encode the linguistic sample by employing techniques such as the fuzzy HEBB matrix. With this methodology, the input is described by an uncertain distribution, or fuzzy, to reduce into scalars through averaging, and the output is deduced using the rule-matrix (Kosko, 1992). For system-wide power quality monitoring, data communication is vitally important. To reduce the burden of the data transmission, the site measurement should be preprocessed and a large amount of redundancy should be removed.

In this paper, a neural-fuzzy classifier is proposed for the pattern recognition problems with uncertain distributions. For describing each pattern to be recognized, the neural networks with the architecture of Frequency Sensitive Competitive Learning and Learning Vector Quantization (FSCL-LVQ) are utilized to derive a set of code words with the given training samples. Finally, the developed fuzzy associative memory (FAM) rule-matrixes, according to the outputs of the FSCL-LVQ, recall the pattern the waveform belongs to. Based on the classifiers, an information system can be built up to monitor power quality over the whole power network.

The paper is organized as follows. The FAM rule-matrix and its application in pattern recognition are analyzed first, in Section 2. Section 3 discusses the FSCL-LVQ networks and the evaluation of the code words. The performance of