Hybrid Approach Based on ANFIS Models for Intelligent Fault Diagnosis in Industrial Actuator

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Abstract- **This paper introduces the application of the hybrid approach Adaptive Neuro-Fuzzy Inference System (ANFIS) for fault classification and diagnosis in industrial actuator. The ANFIS can be viewed either as a fuzzy inference system, a neural network or fuzzy neural network (FNN). This paper integrates the learning capabilities of neural network to the robustness of fuzzy systems in the sense that fuzzy logic concepts are embedded in the network structure. It also provides a natural framework for combining both numerical information in the form of input/output pairs and linguistic information in the form of *if-then* rules in a uniform fashion. The proposed algorithm is achieved by the intelligent scheme ANFIS. This intelligent system is used to model the valve actuator and classify the fault types. Computer simulation results are shown in this paper to demonstrate the effectiveness of this approach for modeling the actuator and for classification of faults for different fault conditions.**

Keywords- Neuro-Fuzzy System; Hybrid Learning; Fault Diagnosis

I. INTRODUCTION

Artificial intelligent techniques, such as artificial neural networks (ANN) fuzzy logic (FL) have been successfully applied to automated detection and fault diagnosis in different conditions [1] [2]. They largely increase the reliability of fault detection and diagnosis systems. The adaptive neuro-fuzzy inference system (ANFIS) [3] is a hybrid model which combines the ANNs adaptive capability and the fuzzy logic qualitative approach (Jang, 1993). By using the mathematical properties of ANNs in tuning rule-based fuzzy systems that approximate the way human process information, ANFIS harnesses the power of the two paradigms: ANNs and fuzzy logic, and overcomes their own shortcomings simultaneously [4] [5].

Fuzzy system is tolerant to noise and error in the information coming from the sensory system, and most importantly; it is a factual reflection of the behavior of human expertise. A fuzzy controller is commonly defined as a system that emulates a human expert. The knowledge of the operator would be presenting in the form of a set of fuzzy linguistic rules [5]. These rules produce an approximate decision in the same manner as an expert would do. Ever since the fuzzy systems were applied in industrial applications, developers know that the construction of a well performing fuzzy system is not always easy.

The problem of finding appropriate membership functions and fuzzy rules is often a tiring process of trial and error. However, the design of fuzzy logic rules is often reliant on heuristic experience and it lacks systematic methodology, therefore these rules might not be correct and consistent, do not possess a complete domain knowledge, and/or could have a proportion of redundant rules. Furthermore, these fuzzy logic rules cannot be adjusted or tuned on real-time operation, and the off-line adjustment of their parameters is a time consuming process. Another problem could be raised when better precision is needed which is the huge expansion in the fuzzy rule-based system [5].

Techniques based on the use of Artificial Neural Networks (ANN) have a great interest in control and engineering. The fastness of treatment and their capacity of approximating complex nonlinear functions motivate their use for fault diagnosis [1] [6] [7]. The learning parameters of neural networks made them a prime target for a given task. This kind of behavior learning methods can be used to solve control and diagnosis problems. Artificial neural networks are considered to be simplified mathematical models of brain-like systems. A neural network is a processor of information which can be represented in its simplest form by a set of connected and layered processing elements (*PEs*). Each *PE* is able of receiving an *n*-dimensional input vector from either external sources or *PEs* at previous layers, and processing the data to deliver a scalar output, which is the function of a present input. They are generally trained by means of training-data, and due their property of generalization, they can learn new associations, new functional dependencies and new patterns. Due to these properties, they have been widely used for control. The learning parameters of neural networks made them a prime target for a combination with a fuzzy system in order to automate or support the process of developing a fuzzy system for a given task. Recently the role of neural networks has been found to be very useful and effective when integrated with fuzzy control systems to produce what is called neuro-fuzzy systems [4]. These hybrid systems provide an urgent synergy can be found between the two paradigms, specifically the capability to mimic human experts in fuzzy logic, and learning from previous experience capability in neural networks. Generally, neuro-fuzzy systems can be classified into two categories, adaptive neuro-fuzzy inference system (ANFIS) [3] and hybrid neuro-fuzzy systems [4]. The first category is the most widely used, and they are designed to combine the learning capabilities of neural networks and reasoning properties of fuzzy logic. The main function of neural network is to learn about the fuzzy inference system (FIS) behavior and uses this knowledge to adaptively modify its parameters. The adaptability of the fuzzy inference system can be achieved