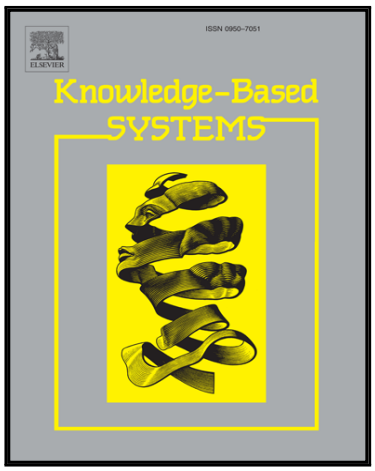

Recent advances in Neuro-fuzzy system: A survey

Shihabudheen KV , G N Pillai

PII: S0950-7051(18)30182-5
DOI: 10.1016/j.knosys.2018.04.014
Reference: KNOSYS 4296

To appear in: *Knowledge-Based Systems*

Received date: 27 September 2017
Revised date: 1 March 2018
Accepted date: 10 April 2018

Please cite this article as: Shihabudheen KV , G N Pillai , Recent advances in Neuro-fuzzy system: A survey, *Knowledge-Based Systems* (2018), doi: 10.1016/j.knosys.2018.04.014

Recent advances in Neuro-fuzzy system: A survey

Shihabudheen KV[a,*], G N Pillai[b]
[a,b]Department of Electrical Engineering, Indian Institute of Technology Roorkee, India.

Abstract— Neuro-fuzzy systems have attracted the growing interest of researchers in various scientific and engineering areas due to its effective learning and reasoning capabilities. The neuro-fuzzy systems combine the learning power of artificial neural networks and explicit knowledge representation of fuzzy inference systems. This paper proposes a review of different neuro-fuzzy systems based on the classification of research articles from 2000 to 2017. The main purpose is to help readers have a general overview of the state-of-the-arts of neuro-fuzzy systems and easily refer suitable methods according to their research interests. Different neuro-fuzzy models are compared and a table is presented summarizing the different learning structures and learning criteria with their applications.

Index Terms— ***Neuro-fuzzy systems, self organizing, Support vector machine, extreme learning machine, recurrent***

1 Introduction

Concerns over computational speed, accuracy and complexity of design made researchers think about soft computing techniques for modelling, prediction and control applications of dynamic nonlinear systems. Artificial neural networks (ANN) and fuzzy logic systems are commonly used soft computation techniques. Fusion of these two techniques is proliferating into many scientific and engineering fields to solve the real world problems. Use of fuzzy logic can directly improve the reasoning and inference in a learning machine. The qualitative, albeit imprecise, knowledge can be modelled to enable the symbolic expression of machine learning using fuzzy logic. Use of neural networks incorporates the learning capability, robustness and massive parallelism into the system. Knowledge representation and automated learning capability of the neuro-fuzzy system make it a powerful framework for machine learning problems [1].

Takagi-Sugeno-Kang (TSK) inference system is the most useful fuzzy inference system and is a powerful tool for modeling of nonlinear dynamic systems. The main advantage of TSK system modeling is that it is a 'multimodal' approach which can combine linear submodels to describe the global behavior of complete complex nonlinear dynamic system [2]. One of the popular neuro-fuzzy approaches, adaptive neuro-fuzzy inference system (ANFIS) has been utilized by researchers for regression, modelling, prediction and control problems [3], [4]. ANFIS uses TSK type fuzzy inference system in a five layered network structure. ANFIS defines two sets of parameters namely premise parameters and consequent parameters. The fuzzy if-then rules define the relationship between the two sets of parameters. The main drawback of ANFIS is that it is computationally intensive and generates complex models for even relatively simple problems.

Nowadays learning methods and network structure in conventional neuro-fuzzy networks are improved to achieve better results in terms of accuracy and learning time. A highly efficient neuro-fuzzy system should have the following characteristics, 1) fast learning 2) on-line adaptability 3) self-adjusting with the aim of obtaining the small global error possible and 4) small computational complexity. This paper surveys improved neuro-fuzzy systems based on their learning criteria, adaptation capability, and network structure.

Different survey papers are available in the literature. J. Jang [5] gives different learning methods of ANFIS and its application in control systems. Case studies are included to support the study. In early 2000, an exhaustive survey on neuro-fuzzy rule generation has been performed in [1]. It explains different ways of hybridization of neural networks and fuzzy logic for rule generation. Neuro-fuzzy rule generation using evolutionary algorithm also explained. R. Fuller [6] presents a survey of neuro-fuzzy systems and explained different types of methods to build a neuro-fuzzy system. The preliminaries of different modeling and identification techniques using the neuro-fuzzy system are detailed in [7] . In 2001, A. Abraham [8] presented different concurrent models, cooperative models and fully fused