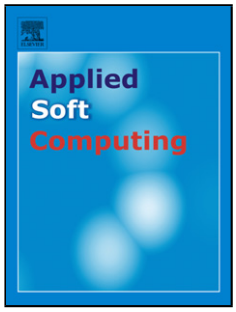

Title: Adaptive Critic-Based Quaternion Neuro-Fuzzy Controller Design with Application to Chaos Control

Authors: Pouria Tooranjipour, Ramin Vatankhah

PII: S1568-4946(18)30335-1
DOI: https://doi.org/10.1016/j.asoc.2018.06.012
Reference: ASOC 4926

To appear in: *Applied Soft Computing*

Received date: 10-12-2017
Revised date: 14-5-2018
Accepted date: 8-6-2018

Please cite this article as: Tooranjipour P, Vatankhah R, Adaptive Critic-Based Quaternion Neuro-Fuzzy Controller Design with Application to Chaos Control, *Applied Soft Computing Journal* (2018), https://doi.org/10.1016/j.asoc.2018.06.012

Adaptive Critic-Based Quaternion Neuro-Fuzzy Controller Design with Application to Chaos Control

Pouria Tooranjipour[a], Ramin Vatankhah[a, 1]

[a] School of Mechanical Engineering, Shiraz University, Shiraz, Irans

[1] Corresponding author. Email Address: rvatankhah@shirazu.ac.ir,
Tel.: +98 71 36133248; fax: +98 71 36473511.

Abstract: Neuro-fuzzy control structures despite all of the advantages from both neural networks features and fuzzy inference engines always get in trouble due to a large number of fuzzy rules which is because of the high order of the system or the large number of divisions considered for each input. In this paper, a new adaptive neuro-fuzzy controller is proposed based on the quaternion numbers, and thus the mentioned problem of large rule numbers is solved by using the quaternion back propagation concept. Furthermore, utilizing reinforcement learning which assesses output value produced by a critic is another strength of the proposed method. Finally, in order to show the superiority and effectiveness of the proposed controller in comparison with conventional neuro-fuzzy ones, a complex and challenging chaos control problem which is a chaotic spinning disk control is provided.

Keywords: Quaternion neuro-fuzzy control, Reinforcement learning, Critic design, Quaternion back-propagation

1. Introduction

Thanks to the advent of neural networks, control problems have taken on a new dimension. As a result, identification of plants have been more powerful and easier with more freedom than before because of many gains are trained with optimization algorithms [1, 2]. The main problem is that such networks cannot be trained by human experts, so a distinct perception about the system cannot be accurately reached. Therefore, the conventional fuzzy systems are created for fulfilling these flaws by introducing the linguistic variables. In recent years, utilizing fuzzy logic systems (FLS) in the controller design of uncertain systems due to their universal approximation property has attracted much attention [3-6]. For example, in [3], for switched nonlinear systems, an adaptive output-feedback control with prescribed functions are suggested, and fuzzy logic is used to address the uncertainty existed in the nonlinear system. In [5], an adaptive fuzzy sliding mode control is proposed for 3-DOF planar robot manipulators. The remarkable resemblance of how FLS is applied in aforementioned works is that the parameters of membership functions are updated by adaptation laws exploited from Lyapunov stability theorem. In spite of the advantageous of applying conventional FLS, there remain a number of shortcomings in the