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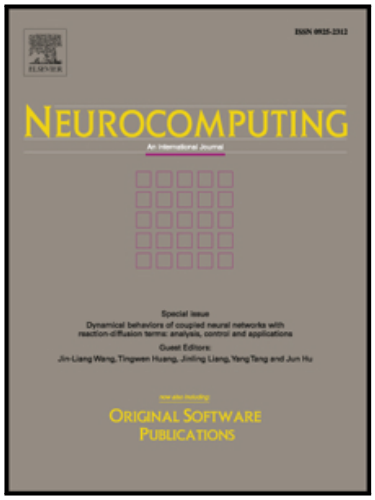

The Universal Consistency of Extreme Learning Machine

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The Universal Consistency of Extreme Learning Machine

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Abstract

Extreme learning machine (ELM) can be considered as a single-hidden layer feedforward neural network (FNN)-type learning system, whose input weights and hidden layer biases are randomly assigned, while output weights need tuning. In the framework of regression, a fundamental problem of ELM learning is whether the ELM estimator is universally consistent, that is, whether it can approximate arbitrary regression function to any accuracy, provided the number of training samples is sufficiently large. The aim of this paper is two-fold. One is to verify the strongly universal consistency of the ELM estimator, and the other is to present a sufficient and the necessary condition for the activation function, where the corresponding ELM estimator is strongly universally consistent. The obtained results underlie the feasibility of ELM and provide a theoretical guidance of the selection of activation functions in ELM learning.

Keywords: Extreme learning machine, neural networks, universal consistency, activation function.

1. Introduction

Extreme learning machine (ELM), proposed by Huang et al. [11], is a special single-hidden layer feedforward neural network (FNN) learning system, whose input weights and hidden layer biases are randomly assigned. ELM then only needs to adjust the output weights which leads to ELM learning being a linear learning problem. Obviously, the computational burden of ELM learning is significantly less than that of the classical FNN training [9]. Various experimental studies [11, 13, 17] showed that such a computa-

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