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IRBM

IRBM 36 (2015) 240–249

Original article

Analysis of PSO, AIS and GA-based optimal Wavelet-Neural Network classifier in Brain–Robot Interface

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Received 30 June 2014; received in revised form 22 April 2015; accepted 24 April 2015

Available online 2 June 2015

Abstract

Objectives: This paper studies the effectiveness of three classifiers (Particle Swarm Optimization (PSO) based optimal Wavelet Neural Network (WNN), Artificial Immune System (AIS) based optimal WNN and Genetic Algorithm (GA) based optimal Neural Network) in Brain–Robot Interface system.

Material and methods: C3 & C4 are selected as inputs. Wavelet coefficients, auto-regressive and the power of wavelet coefficients are employed as features. WNN is used as classifier and its performance in terms of accuracy is improved through meta-heuristic optimization techniques (PSO, AIS and GA). They are used to optimize neural network weights and wavelet parameters.

Results: Accuracy of three classification algorithms: a) PSO-based optimal WNN, b) AIS-based optimal WNN and c) GA-based optimal ANN is calculated. Results show that the mean accuracy/standard deviation of a), b) and c) are 76%/4.9, 65%/2.6 and 64%/2.2, respectively. In addition, results of the best classifier (PSO-based optimal WNN), are compared with Support Vector Machine (the mean accuracy of SVM is 60%).

Conclusion: PSO-based optimal WNN results in the best classification accuracy. Outputs of this classifier are implemented on a mobile robot named K-junior and a fixed robot named Tabriz-Puma. The experimental results show the applicability and effectiveness of these methods.

1. Introduction

Electroencephalogram (EEG) signals provide useful information for implementation of interfacing technology between human's brain and a machine. They have possible applications in rehabilitation at the next generation of prosthetic devices [1]. Brain–Robot Interface (BRI) allows the brain to control a robot directly, without any physical movement achieved through normal neuromuscular pathways [2]. The EEG signals contain information associated with movements, mental tasks or mental responses. These neurophysiological rhythms are recorded from electrodes site inside (invasive) or outside (non-invasive) the brain [3,4].

Generally, feature extraction methods for the motor imagery EEG include the following:

a) Deriving time domain features, i.e. energy and amplitude of signal.
b) Establishing frequency domain features.

Fast Fourier Transform (FFT) and Auto-Regressive (AR) spectral analyses are examples of methods that are used. In addition, coefficients AR or Multivariate Auto-Regressive (MVAR) model are used as features [5]. The main disadvantage of this method is to neglect time domain information because when a signal is studied in frequency domain, its temporal information is lost.

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http://dx.doi.org/10.1016/j.irbm.2015.04.001
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