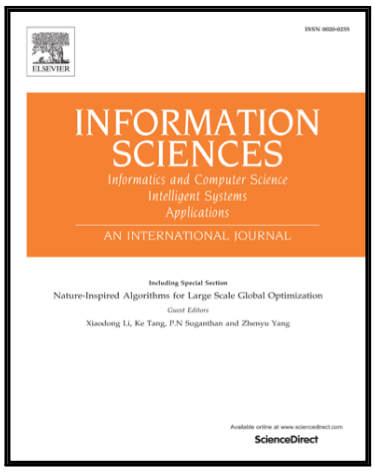

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Unsupervised EEG Feature Extraction Based on Echo State Network

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Abstract

Advanced analytics such as event detection, pattern recognition, clustering, and classification with electroencephalogram (EEG) data often rely on extracted EEG features. Most of the existing EEG feature extraction approaches are hand-designed with expert knowledge or prior assumptions, which may lead to inferior analytical performances. In this paper, we develop a fully data-driven EEG feature extraction method by applying recurrent autoencoders on multivariate EEG signals. We use an Echo State Network (ESN) to encode EEG signals to EEG features, and then decode them to recover the original EEG signals. Therefore, we name our method feature extraction based on echo state network, or simply FE-ESN. We show that the well-known autoregression-based EEG feature extraction can be seen as a simplified variation of our FE-ESN method. We have conducted experiments on real-world EEG data to evaluate the effectiveness of FE-ESN for both classification tasks and clustering tasks. Experimental results demonstrate the superiority of FE-ESN over the state-of-the-art methods. This paper not only provides a novel EEG feature extraction method but also opens up a new way towards unsupervised EEG feature design.

Keywords: EEG Signals, Feature Extraction, Echo State Network, AutoEncoder
2010 MSC: 00-01, 99-00

1. Introduction

By recording the electrical activity of the brain, electroencephalography (EEG) can reflect the physiology and functions of the brain and serves as one of the most important diagnostic procedures for neurological diseases. For example, in the EEG of an epilepsy patient, two categories of abnormal activity can be observed: ictal (during an epileptic seizure) and interictal (between seizures). Recording

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