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Advances on Brain Inspired Computing

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This special issue of Cognitive Computation includes 11 original articles, which have been selected among the highest quality submissions to the 2012 Brain Inspired Cognitive Systems (BICS 2012) Conference. BICS 2012 provided a high-level international forum for scientists, engineers, and educators to present the state-of-the-art research on brain inspired computing and cognitive systems, with applications in multi-disciplinary fields. The conference featured plenary speeches given by worldwide renowned scholars, regular sessions with broad coverage, and some special sessions focusing on interesting topics for the related scientific community.

Based on the recommendation of symposium organizers and reviewers, a number of authors were invited to resubmit an extended version of their contributions, originally submitted as conference papers, for this special issue of Cognitive Computation. All these journal articles went through the same rigorous review procedure by at least three independent experts before being accepted for publication.

This special issue focuses on recent advancements in the field of brain inspired computing. The selected 11 articles can be divided into two main groups. The first group consists of four papers, and it is more oriented to new architectures and algorithms, whereas the second group contains the remaining seven papers, dealing with challenging applications in diverse areas.

The special issue starts with the first group of papers and with the contribution by Kozma and Puljic, titled "Learning Effects in Coupled Arrays of Cellular Neural Oscillators," where the authors analyze the spatio-temporal dynamics of coupled neural oscillatory arrays. In particular, a neuropercolation model encompassing the Freeman principles of neurodynamics is used, and the modulation effects due to distributed input biases in interconnected excitatory-inhibitory oscillators spanning the lattice graph are investigated. It is shown that the proposed neuropercolation model is able to generate large-scale synchronized, narrow-band oscillations in response to learned stimuli, as observed in EEG and ECoG experiments.

The second contribution by Xunan Zhang et al., addresses the Bayesian classification problem in the presence of incomplete data. The usual approach adopted in the literature consists in simply ignoring the samples with missing values or imputing missing values before classification. This is not really effective when the amount of missing values is considerable and/or the data acquisition phase is expensive. The authors thus propose an innovative expectation–maximization-based learning algorithm, applying it to a multivariate Gaussian mixture model and a multiple kernel density estimator. Such a technique is able to avoid list-wise deletion or mean imputation in solving classification tasks with incomplete data. Experimental tests on several benchmark problems and also on practical classification tasks on the lithology identification of hydrothermal minerals and license plate character recognition have shown that the proposed approach shows remarkable classification

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accuracies with respect to the existing methodologies that have so far appeared in the literature.

The paper "Mussels Wandering Optimization: An Ecological-inspired Algorithm for Global Optimization" by Jing An et al. is about a novel meta-heuristic algorithm called Mussels Wandering Optimization. It is an innovative optimization algorithm, ecologically inspired by mussels' leisurely locomotion behavior when they constitute bed patterns in their habitat. The approach consists in a landscape-level evolutionary mechanism of pattern distribution by means of a stochastic decision and the Levy walk paradigm. Several computer simulations have been performed, and the effectiveness of the proposed technique have been evaluated over a consistent set of complex optimization benchmarks.

Guotao Hui et al. in the contribution entitled "Quantized Control Design for Coupled Dynamic Networks with Communication Constraints" deals with the quantized synchronization control problem of coupled dynamic networks (CDNs) with communication constraints. The approach is based on a new closed-loop coupled dynamic system, where both the interval time-varying delays and quantized parameters are considered. By means of the Kronecker product and using the Lyapunov–Krasovskii functional approach, a stability criterion is obtained for the closed-loop CDNs, which also guarantees the network synchronization. Some computer simulations also confirm the effectiveness of the proposed method.

Then, the special issue continues with the second group, which starts with the paper by Liu Yang et al., namely "Underdetermined Blind Source Separation by Parallel Factor Analysis in Time–Frequency Domain." An innovative time–frequency approach for the underdetermined blind source separation problem is proposed in this work. The algorithm makes use of the parallel factor decomposition of third-order tensors. It is able to provide source separation without any constraint on the number of active sources at an auto-term time–frequency point and satisfying the uniqueness condition of parallel factor decomposition. The proposed method shows a certain robustness to input noise and allows estimating the mixing matrix during the source separation process. Some computer simulations are presented to show the superior performance of the proposed approach to some state-of-the-art two-stage blind source separation methods, also based on time–frequency representation.

In the work by Liang Zhong et al., entitled "Distributed Interference Alignment Algorithm for Multiple-Input Multiple-Output Networks with Uncoordinated Interference," a novel two-step interference alignment beamforming algorithm for a multiple-antenna application scenario in the presence of uncoordinated interference is proposed. The proposed algorithm performs a subspace division of the signal space by using the total least squares method, maximizing the system sum rate. Simulations prove that superior performance with respect to state-of-the-art techniques is achievable in different operating conditions.

Another contribution in this application-oriented group of papers is represented by "Automatic Removal of Artifacts from Attention Deficit Hyperactivity Disorder Electroencephalograms based on Independent Component Analysis" by Ling Zou et al., proposing an automatic artifact removal method by combining independent component analysis (ICA) and wavelet denoising to remove artifacts from Attention Deficit Hyperactivity Disorder electroencephalograms. First, the ICA algorithm is used to analyze the input EEG signals; then, the wavelet-based algorithm is then applied to the demixed components, and the related output signals are processed to reconstruct the EEG data by using the inverse ICA. Simulations show that the automatic artifact removal method not only can remove eye artifacts, muscle artifacts, and some unknown physiological artifacts sources, but can also efficiently distinguish the weak neural activities from strong background artifacts.

The work by Qiu-Feng Wang et al. is about the "Common Sense Knowledge for Handwritten Chinese Text Recognition." In this work, the authors investigate the effects of employing commonsense knowledge as a new linguistic context in handwritten Chinese text recognition. In particular, three different models are addressed in a complementary perspective with respect to the standard n-gram language paradigm. The first one is an embedding model, which uses semantic similarities from commonsense knowledge to make the n-gram probabilities estimation more reliable, especially for the unseen n-grams in the training text corpus. The second one is based on a direct approach, considering the linguistic context of the whole document to make up for the short context limit of the n-gram model. Finally, the third one is a smart combination of the former two. Computer simulations, carried out by employing a large unconstrained handwriting database, show that the adoption of commonsense knowledge according to the aforementioned models allows improvement in the overall recognition accuracy.

Then, we have the contribution proposed by Bin Xia et al., proposing an "Asynchronous Brain-Computer Interface Based on Steady-State Visual Evoked Potential." The authors move from the assumption that in asynchronous brain-computer interface (BCI) systems, a key challenge is represented by the ability to discriminate intentional control and non-intentional control states. Their contribution proposes an innovative two-stage asynchronous protocol for a steady-state visual evoked potential-based BCI. In the first stage, a suitable threshold is estimated by using a canonical correlation analysis in synchronous mode, whereas in the second one, such a threshold is combined with a sliding windows mechanism for automatic and continuous detection of the user mental state, adequately detecting when

intentional controls occur. Experimental results comparable with the state-of-the art techniques are achieved by means of the proposed methodology.

Z. J. Jia et al. present their innovative "Bio-Inspired Approach for Smooth Motion Control of Wheeled Mobile Robots" in their contribution. Wheeled Mobile Robots (WMRs) have been largely addressed by the academic community in the recent past, and many applications have appeared both in civilian and military fields. One of the key aspects to consider is the capability to provide a smooth and stable motion of WMRs, not only for enhancing control accuracy and facilitating mission completion, but also for reducing mechanical tearing and wearing. In this work, the authors present a novel bio-inspired approach aiming at significantly reducing motion chattering phenomena inherent with traditional methods related to the development of smooth motion controller. The main innovation carried out in the proposed approach consists in the involvement of a pre-processing stage to manipulate the speed commands with the help of fuzzy rules to generate more favorable movement for the actuation device. This allows to effectively avoid the jitter problem that has not yet been adequately solved by traditional methods. Smooth and asymptotically stable WMR tracking, consistent with the desired position and orientation, is ensured as confirmed by real-time experiments.

In conclusion, in the Boaro et al. paper, entitled "Adaptive Dynamic Programming Algorithm for Renewable Energy Scheduling and Battery Management", an innovative neural-network-based approach for optimal home energy resource scheduling management is proposed. The objective consists in scheduling the available energy resources, satisfying the load demand, and minimizing the overall energy cost. In particular, an adaptive dynamic programming based algorithm is presented to face dynamic situations in smart home scenarios, in which some conditions of the environment or habits customer may vary with time. An advanced management scheme for renewable resources combined with a storage system is developed: It is based on a reduced complexity implementation of the dynamic programming paradigm, by considering only one critic network and some optimization policies in order to satisfy the load demand. As a result of this approach, the action network training is completely avoided as well as the training loop between the two neural networks, and the overall training process is greatly simplified. Computer simulations confirm the effectiveness of the proposed self-learning design in a typical residential scenario.

Finally, as guest editors, we would like to thank all authors for their noteworthy contributions to this special issue. We also would like to express our sincere appreciation to all reviewers for their time and efforts and to the Cognitive Computation Editorial Board for the substantial support in the whole organizing process.