**1. Introduction**

This special issue covers some recent advances on bioinspired and knowledge-based techniques with some emphasis on applications to the medical domain, specifically in medical image processing. Some of the papers have been selected from the KES 2012 conference, and other have been contributed by authors outside the conference. The special issue covers a wide spectrum of techniques which we have clustered in three categories for this editorial: medical image processing, bioinspired optimization approaches, and miscellaneous applications of bioinspired computational methods.

The paper by Padilla et al. [35] tackles with the difficult problem of intensity normalization of single-photon emission computed tomography (SPECT) 3D functional images. It is well known that the distribution of intensity values of SPECT images is subject dependent, which impedes quantitative group studies [3,39]. Hence a proper normalization of the image intensities, ensuring that intensity values have equivalent meaning for all subjects, is required previously for other processes, such as spatial normalization, or feature extraction for the construction of CAD systems [21]. The approach proposed in [35] models the intensity by $\alpha$-stable distributions, a generalization of the Gaussian distribution satisfying the Generalized Limit Central Theorem. The normalization process transforms the individual distributions into a reference $\alpha$-stable as close as possible to a Gaussian distribution. The authors report empirical results on the effect of diverse intensity normalization procedures on the predicted accuracy of CAD systems tested on a dataset from a study on Parkinson Syndrome.

The paper by Angelopoulos et al. [1] provides a bioinspired approach to the segmentation and 3D modeling of the brain ventricles from high resolution structural MRI, allowing precise morphological measurements for longitudinal studies on degenerative diseases which show effects on the ventricles volume and morphology. The approach is based on the Growing Neural Gas (GNG) [14] adaptive architecture for data clustering, which is able to find non-linear manifolds in the data space. The GNG topology provides the morphological description of the ventricle, which is later rendered to surface visualization by interpolation of the GNG units localization. The authors provide also a high speed implementation in Graphical Processing Units (GPU) which provides almost real-time response.

The paper by Chyzhyk et al. [7] deals with the problem of lesion segmentation in multimodal MRI data, a critical problem for the correct processing of the data provided on studies of diverse pathologies that show some kind of damaged tissue. Lesions distort the normal anatomical outline in structural MRI, and introduce strong artifacts also on other kind of MRI data. In [7] the approach followed is the design of classifier based interactive segmentation by Active Learning [30] on the basis of features extracted from the MRI data. Active Learning needs the definition of a classification uncertainty, which is easily computed from the collective outputs of Random Forest classifiers. The approach is demonstrated on data from a study on cognitive recovery after Stroke [10,9] which provides functional MRI, Fluid Attenuated Inversion Recovery (FLAIR), Diffusion Weighted Imaging (DWI), as well as T1 and T2 weighted MRI. The results explore the effect of diverse feature transformations and selection on the accuracy and
speed of convergence of the Active Learning approach for classification based lesion segmentation.

The paper by Papakostas et al. [36] introduces a Lattice Computing (LC) [22,37,32,15,47,17,16] approach for the construction of CAD systems on Alzheimer’s Disease [45] prediction based on features extracted from structural Magnetic Resonance Imaging (MRI) data, i.e., T1-weighted data. In the LC paradigm, the main algorithm building blocks are the operations in a Lattice algebra. The LC approach to machine learning is therefore founded in Lattice Theory. The approach proposed in [36] consists in the definition of a LC-kNN classifier based on the distance defined on the Intervals Numbers constructed from the empirical distributions of the features. The approach is demonstrated on the deformation based features extracted from a subset of the Open Access Series of Imaging Studies (OASIS) database [31] against previously published results on the same dataset.

3. Optimization

The paper by Caamaño et al. [4] deals with the extension of a neuroevolutive approach, namely the Neuroevolution of Augmenting Topologies (NEAT), to the case of time series data. The NEAT algorithm provides both the network structure and the estimation of the weights. The proposed approach, called r-NEAT, allows us to introduce variable delays in the artificial neural network synapses for both direct and recurrent synapses. This approach results from a direct application of the embedding theorem to the Artificial Neural Network design, providing substantial improvements on benchmarking datasets.

The paper by Wang et al. [48] deals with multi-objective optimization problems introducing an enhancement of the well known Non-dominated Sorting Genetic Algorithm II (NSGA-II) [11] by the use of set of experience knowledge structures (SOEKS) [41,40,46]. The SOEKS encodes the knowledge obtained from previous running of optimization algorithms in order to guide the parameter selection of the NSGA-II algorithm, leading to a Smart Experience-based Data Analysis System (SEDAS), which achieves optimal tuning of the multi-objective genetic algorithm over a specific domain of combinatorial problems. The experimental results reported on benchmark instances of the Traveling Salesman algorithm provide an empirical endorsement of the paper claims.

The paper by Matei et al. [33] proposes several innovations on the classic genetic algorithm intended to improve its performance on the problem of vehicle routing for a fleet of heterogeneous vehicles [42,44]. The problem is a multi-objective problem in essence, minimizing fleet size and diversity as well as the overall cost while maximizing the number of routes served. The innovations proposed include some specific local search heuristics, which account for the memetic aspect of the approach, and an immigration strategy improving population diversity towards enhanced space exploration. Results are reported on a collection of benchmark fleet design problems.

The paper by Cuesta Infante et al. [8] attacks the problem of the physical layout design for 3D chips, aiming to minimize problems such as hotspots that endanger the sustained performance of the chip, as well as wire length. The design tasks are, therefore, a multi-objective optimization problem. The first cost function may be well approximated by a 3D Manhattan distance, while the second needs a detailed physical modeling of the heat diffusion in the chip. The paper presents five random search algorithms to solve this task, three based on Simulated Annealing (SA) and two evolutionary computation approaches. Each algorithm uses a specific representation of the task and specific operators to carry out the exploratory and selective processes. Moreover, the cost functions are used in specific ways by each algorithm. SA-based algorithms cannot perform multi-objective optimization, thus specific scalar cost function is computed by parametric combinations of wirelength and temperature costs. Results on benchmark architectures compare well with the literature.

The paper by Bankovic et al. [2] exploits the evolutionary multi-objective approach, namely adapting the NSGA-II algorithm [11], for the task of optimizing the allocation of processes to processors in a multi-processor multi-thread architecture, taking into account computational time as well as energy consumption. Detailed modeling of the physical processes is provided to define the cost functions. The authors report improved performance when assuming a stochastic model of the workload instead of a deterministic one.

4. Miscellaneous applications

The paper by Casteliero-Roca et al. [6] deals with a very innovative application of bioinspired computational algorithms to the control of new generation buildings designed under very strict ecological regulations for energy and environment preservation: a bioclimatic house. Specifically, the house has a geothermal heat exchanger adding to the solar and biomass sources of energy for heating and domestic hot water. The problem posed by the geothermal heat exchanger is its disturbing effect on the ground temperature and the effect of the weather conditions on the heat exchanger. Global and local bioinspired approaches, such as the Multilayer Perceptron, Support Vector Regression, and Self-Organizing Map (SOM), were applied to real measurements, with some hybridization [5], aiming to obtain a reliable predictor of the performance of the system under varying conditions.

The paper by Lin et al. [24] introduces innovative group based methods for document ranking [29] based on a hierarchical approach. Documents are gathered into groups by the value of their relevance labels to a given query, so that the ranking process of minimizing a given loss function is defined on the groups of documents instead of the individual documents [23], achieving a huge reduction in computational cost. Moreover, ranking function is built by training a single layer artificial neural network by minimization of the group ranking loss functions. Results on several loss functions over standard document ranking benchmark databases are provided.

The paper by Piñola et al. [38] deals with the problem of selecting the most informative image descriptors in order to perform searches on image databases. The selection process is stated as Reinforcement Learning [43] problem, solved by applying a Q-learning approach. The image descriptors are selected from conventional local feature descriptors, such as SIFT, SURF, and PHOW [34]. The effect of the state definition is studied empirically, showing that a combination of the state descriptors achieves optimal retrieval results, implying the use of several state-action value tables simultaneously to solve the problem.

The paper by Lopez-Guede et al. [27] deals with the optimization of a Reinforcement Learning approach to learning the control of a linked multicompartment robotic system (L-MCRS) [12] performing the task of carrying the tip of a hose to some specific position in the working space [13,25,26,28]. This optimization is achieved by the functional approximation of the state transition and state-action value functions by Extreme Learning Machines (ELM) [20]. The quick learning of ELMs allows us to update these function representations during the reinforcement learning process, so that larger systems can be attacked to learn their control.

References
