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EDITORIAL

Neural Computation links Neuroscience: a synergistic approach

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For several decades, computing science and neuroscience benefit from fruitful synergy. This special issue searches to make a step forward by providing an overview of how the new advancements in computing sciences strengthen and enrich this synergy. The general aim of this special issue, continuing the neurocybernetic concepts from Wiener and W.S. McCulloch, is to present a wider and more comprehensive relation of the computational paradigm (CP), with emerging neuroscience studies. The secondary objectives are also (1) to help neuroscience and cognitive science, by explaining the latter as a result of the former, (2) to establish an interaction framework between neural computation and neuroscience by posing a series of appropriate questions in both directions of the interaction, from artificial systems to neural systems, and from neural systems to artificial systems.

Nowadays, machine learning holds great promise in the development of new models and theories in the field of neuroscience, in conjunction with classical statistical hypothesis testing. Machine learning algorithms have the potential to reveal interactions, hidden patterns of abnormal activity, brain structure and connectivity and physiological mechanisms of brain and behavior. In addition, several approaches for testing the significance of the machine learning outcomes have been successfully proposed to avoid "the dangers of spurious findings or explanations void of mechanism" utilizing proper replication, validation and hypothesis-driven confirmation.

Therefore, these new trends in machine learning can effectively provide relevant information to take great strides toward understanding how the brain works. The main goal of this field is to build new and redesign old bridges between the two scientific communities, the artificial intelligence community, including deep learning and related applications within pattern recognition, and the neuroscience community.

Deep learning has meant a breakthrough in the artificial intelligence community. The best performances attained so far in many fields, such as computer vision or natural language processing, have been overtaken by these novel paradigms up to a point that only 10 years ago was just science fiction. In addition, this technology has been open-sourced by the main AI companies, hence making quite straightforward to design, train and integrate deep-learning-based systems. Moreover, the amount of data available every day is not only enormous, but growing at an exponential rate. Over the last years, there has been an increasing interest in using machine learning methods to analyze and visualize massive data generated from very different sources and with many different features: social networks, surveillance systems, smart cities, medical diagnosis, business, cyberphysical systems or media digital data. The design of neural systems based on neuroscience with high computing requirements evidence opens a huge opportunity for new applications.

The International Work conference on the Interplay between Natural and Artificial Computation (IWINAC) meeting brought successfully together researchers in neurobiology, computational neuroscience and artificial intelligence. After the meeting, research involving neuroscience and computation grows together with the novel developments of both disciplines: Neuroscience is the branch of science when the discoveries of the century take place, and computing elements are becoming omnipresent, cheaper and more skillful, often thanks to interdisciplinary approaches. The positive outcome of that experience encouraged us in further exploration on the intersection of these disciplines in the hope to find new paradigms and techniques. This Neural Computing and Applications special issue covers the extended and updated versions of a set of the works presented at IWINAC conference.

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Three different objectives can be used as a framework for integrating the different research outcomes in this Neural Computing and Applications special issue. The first one refers to biological or bioinspired models related to neuroscience studies that support the neurocomputation, the second one is related to neuromorphic approaches to different real-world applications, and the last one focuses on neural approaches to neurological or health research.

The contribution by M. Val et al., "Frequency variation analysis in neuronal cultures for stimulus–response characterization" studies in vitro neuronal cultures embodied in a closed-loop control system that has been used for exploring the computational capabilities of such biological neural networks. Machine learning methods can then be applied to distinguish the electrode being stimulated from the whole culture response, in order to obtain a better characterization of the culture and its computational capabilities, so it can be useful for robotic applications.

The work by A. Cuesta-Infante et al. "Pedestrian detection with LeNet-like convolutional networks" presents a detection method that is able to detect a learned target and is valid for both static and moving cameras. As an application, the system detects pedestrians but could be applied to any dataset of objects.

J.A. Martínez-García et al. in "Performance analysis of No-Propagation and ELM algorithms in classification" studies the so-called linear algorithms for neural networks like ELM, which maintain the precision of classic algorithms but with higher training speed, versus No-Propagation (No-Prop) algorithm, which shares with ELM the architecture and the random input weights (hidden weights) initialization. The simulation results suggest that No-Prop is a competitive alternative to the ELM algorithm.

J. Fombellida et al. in "Tackling business intelligence with bioinspired deep learning" focus on the application of artificial metaplasticity learning in business intelligence systems as an alternative paradigm of achieving a deeper information extraction and learning from arbitrary size data sets. As a case study, an artificial metaplasticity multilayer perceptron applied to the automation of credit approval decisions.

I. Ramirez et al. in "Convolutional neural networks for computer vision-based detection and recognition of dumpsters" propose a twofold methodology for visual detection and recognition of different types of city dumpsters, with minimal human labeling of the image data set. Using a data set that is fully labeled, the paper compares this approach both against a baseline case, doing only the transfer learning using a minimal set of labeled images, and against the best case, using all the labels.

The work by S. Torres-Alegre et al., "AMSOM: artificial metaplasticity in SOM neural networks—application to MIT-BIH arrhythmias database," proposes that metaplasticity, the plasticity of plasticity, is related to learning. Implemented in supervised learning assuming input patterns distribution or a related function, it has proved to be very efficient in performance and training convergence for multidisciplinary applications. A modified self-organization map is applied to the classification of MIT-BIH cardiac arrhythmias database.

B. García-Martínez et al. in "Nonlinear predictability analysis of brain dynamics for automatic recognition of negative stress" studies negative stress, also named distress, one of the most studied emotional states due to its high impact on advanced societies. Its automatic identification from physiological recordings can be extremely useful to prevent concomitant physical health problems as well as other mental disorders. The paper proposes quadratic sample entropy applied to the electroencephalogram signal as the most promising single metric to discern between emotional states of calm and negative stress.

The next article tackles with missing values. A. Sánchez-Morales et al. in "Improving deep learning performance with missing values via deletion and compensation" studies the great representation capability of the stacked denoising auto-encoders that is used to obtain a new method of imputing missing values based on two ideas: deletion and compensation. This method improves imputation performance by artificially deleting values in the input features and using them as targets in the training process.

A. Artetxe et al. in "Balanced training of a hybrid ensemble method for imbalanced datasets: a case of emergency department readmission prediction" present a pipeline method combining random undersampling with bootstrap aggregation for a hybrid ensemble of extreme learning machines and decision trees, whose diversity improves adaptation to the imbalanced class dataset. The approach is demonstrated on a realistic greatly imbalanced data set of emergency department patients from a Chilean hospital targeted to predict patient readmission.

These papers are representative of the current state of the art on the interplay between neuroscience and computation in sensorial systems, and its counterparts in robotics, artificial vision, electronic implementations, neurological disease monitoring, etc. Furthermore, these works stand out from the contributions to the International Work conference on the Interplay between Natural and Artificial Computation. We are still far away from finding an acceptable solution to understanding the brain, its semantics, and building similar neuro-inspired systems. However, we hope that these contributions to Neural Computing and Applications special issue facilitate the meeting between Neuroscience and Neural Computation.