Lecture Notes in Computer Science **11487**

Commenced Publication in 1973
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From Bioinspired Systems and Biomedical Applications to Machine Learning

8th International Work-Conference on the Interplay
Between Natural and Artificial Computation, IWINAC 2019
Almería, Spain, June 3–7, 2019
Proceedings, Part II

Springer

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ISSN 0302-9743 ISSN 1611-3349 (electronic)
Lecture Notes in Computer Science
ISBN 978-3-030-19650-9 ISBN 978-3-030-19651-6 (eBook)
https://doi.org/10.1007/978-3-030-19651-6

LNCS Sublibrary: SL1 – Theoretical Computer Science and General Issues

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Preface

Bio-inspired computing methods take inspiration from nature to develop optimization and search algorithms or metaheuristics, typically in order to tackle the search for optimal solutions of complex problems in science and engineering, which usually imply a high dimensionality of the search space. The interplay between natural and artificial computation creates new paradigms not only in computer science but also in medicine and biology. The hybridization between social sciences and social behaviors with robotics, between neurobiology and computing, between ethics and neuroprosthetics, between cognitive sciences and neurocomputing, and between neurophysiology and marketing, will give rise to new concepts and tools that can be applied to ICT systems, as well as to natural science fields. Through IWINAC, we provide a forum in which research in different fields can converge to create new computational paradigms that are on the frontier between neural and biomedical sciences and information technologies.

As a multidisciplinary forum, IWINAC is open to any established institutions and research laboratories actively working in the field of natural or neural technologies. But beyond achieving cooperation between different research realms, we wish to actively encourage cooperation with the private sector, particularly SMEs, as a way of bridging the gap between frontier science and societal impact. In this edition, four main themes outline the conference topics: Affective Computing, Machine Learning Applied to NeuroScience, Deep Learning, and Biomedical Applications.

Emotions are essential in human–human communication, cognition, learning and rational decision-making processes. However, human–machine interfaces (HMIs) are still not able to understand human feelings and react accordingly. With the aim of endowing HMIs with the emotional intelligence they lack, affective computing science focuses on the development of artificial intelligence by means of the analysis of affects and emotions, such that systems and devices may be able to recognize, interpret, process and simulate human feelings.

Today, the evaluation of electrophysiological signals plays a key role in the advancement toward that purpose since they are an objective representation of the emotional state of an individual. Hence, the interest in physiological variables like electroencephalogram, electrocardiogram, or electrodermal activity, among many others, has notably grown in the field of affective states detection. Furthermore, emotions have also been widely identified by means of the assessment of speech characteristics and facial gestures of people under different sentimental conditions. It is also worth noting that the development of algorithms for the classification of affective states in social media has experienced a notable boost in the last years. In this sense, language of posts included in social networks, such as Facebook or Twitter, is evaluated with the aim of detecting the sentiments of the users of these media tools. Affective computing and sentiment analysis is intended to be a meeting point for researchers that are interested in any of those areas of expertise related to sentiment

analysis and who want to initiate their studies or are currently working on these topics. Hence, manuscripts introducing new proposals based on the analysis of physiological measures, facial recognition, speech recognition, or natural language processing in social media are examples on affective computing and sentiment analysis.

Currently, machine learning holds great promise in the development of new models and theories in the field of neuroscience, in conjunction with classic 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 the 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" by means of proper replication, validation, and hypothesis-driven confirmation. Therefore, 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 a bridge between two scientific communities, the machine learning community, including lead scientists in deep learning and related areas in pattern recognition and artificial intelligence, and the neuroscience community.

Deep learning has represented a breakthrough for 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 ten years ago was just science fiction. In addition, this technology has been open sourced by the main AI companies, hence making it 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 past few years there has been 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. This topic is designed to serve researchers and developers to publish original, innovative, and state-of-the art machine learning algorithms and architectures to analyze and visualize large amounts of data.

Finally, biomedical applications are essential in IWINAC meetings. For instance, brain–computer interfaces (BCI) implement a new paradigm in communication networks, namely, brain area networks. In this paradigm, our brain receives input data (external stimuli), performs multiple media-access controls by means of cognitive tasks (selective attention), processes the information (perception), takes a decision (cognition) and, eventually, transmits data back to the source (by means of a BCI), thus closing the communication loop. Image understanding is a research area involving both feature extraction and object identification within images from a scene, and a posterior treatment of this information in order to establish relationships between these objects with a specific goal. In biomedical and industrial scenarios, the main purpose of this discipline is, given a visual problem, to manage all aspects of prior knowledge, from study start-up and initiation through data collection, quality control, expert independent interpretation, to design and development of systems involving image processing capable of tackle with these tasks. These areas are clear examples of innovative applications in biology or medicine.

The wider view of the computational paradigm gives us more elbow room to accommodate the results of the interplay between nature and computation. The IWINAC forum thus becomes a methodological approximation (set of intentions, questions, experiments, models, algorithms, mechanisms, explanation procedures, and engineering and computational methods) to the natural and artificial perspectives of the mind embodiment problem, both in humans and in artifacts. This is the philosophy that continues in IWINAC meetings, the "interplay" movement between the natural and the artificial, facing this same problem every two years. This synergistic approach will permit us not only to build new computational systems based on the natural measurable phenomena, but also to understand many of the observable behaviors inherent to natural systems.

The difficulty of building bridges between natural and artificial computation is one of the main motivations for the organization of IWINAC 2019. The IWINAC 2019 proceedings contain the works selected by the Scientific Committee from nearly 200 submissions, after the refereeing process. The first volume, entitled *Understanding the Brain Function and Emotions*, includes all the contributions mainly related to the new tools for analyzing neural data, or detecting emotional states, or interfacing with physical systems. The second volume, entitled *From Bioinspired Systems and Biomedical Applications to Machine Learning*, contains the papers related to bioinspired programming strategies and all the contributions oriented to the computational solutions to engineering problems in different application domains, as biomedical systems, or big data solutions.

An event of the nature of IWINAC 2019 cannot be organized without the collaboration of a group of institutions and people whom we would like to thank now, starting with Universidad Nacional de Educación a Distancia (UNED) and Universidad Politécnica de Cartagena. The collaboration of the Universidad de Granada and Universidad de Almeria was crucial, as was the efficient work of the local Organizing Committee, chaired by Juan Manuel Gorriz Sáez with the close collaboration of Manuel Cantón Garbín, Manuel Berenguel Soria, Javier Ramírez Pérez de Inestrosa, Andrés Ortiz García, Francisco Jesús Martínez Murcia, Diego Salas González, Ignacio Álvarez Illán, Fermín Segovia Román, and Diego Castillo Barnés. In addition to our universities, we received financial support from the Spanish CYTED, Red Nacional en Computación Natural y Artificial, Programa de Grupos de Excelencia de la Fundación Séneca and Apliquem Microones 21 s.l.

We want to express our gratitude to our invited speakers, Prof. Hojjat Adeli (Ohio State University, USA), Prof. Francisco Herrera (Universidad de Málaga, Spain), Prof. John Suckling (University of Cambridge, UK), and Prof. Hiroaki Wagatsuma (Kyushu Institute of Technology, Japan), for accepting our invitation and for their magnificent plenary talks. We would also like to thank the authors for their interest in our call and the effort in preparing the papers, condition sine qua non for these proceedings. We thank the Scientific and Organizing Committees, in particular the members of these committees who acted as effective and efficient referees and as promoters and managers of preorganized sessions on autonomous and relevant topics under the IWINAC global scope. Our sincere gratitude also goes to Springer and to Alfred Hofmann and his colleagues, Anna Kramer and Elke Werner, for the continuous receptivity, help efforts, and collaboration in all our joint editorial ventures on the

interplay between neuroscience and computation. Finally, we want to express our special thanks to Viajes Hispania, our technical secretariat, and to Chari García and Beatriz Baeza, for making this meeting possible, and for arranging all the details that comprise the organization of this kind of event.

Last year, in 2018, was 10 years without Professor Mira, without his close and friendly presence. We want to dedicate these two volumes of the IWINAC proceedings to Professor Mira's memory.

June 2019

José Manuel Ferrández Vicente
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