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Bio-inspired Systems and Applications

From Robotics to Ambient Intelligence

9th International Work-Conference on the Interplay Between Natural and Artificial Computation, IWINAC 2022
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Proceedings, Part II

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Preface

The main topic of these IWINAC 2022 books is the study of intelligent systems inspired by the natural world, in particular biology. Several algorithms and methods and their applications are discussed, including evolutionary algorithms. Bio-inspired intelligent systems have thousands of useful applications in fields as diverse as machine learning, biomedicine, control theory, telecommunications, and, why not, music and art. These books covers both the theory and practice of bio-inspired artificial intelligence, along with providing a bit of the basis and inspiration for the different approaches. This is a discipline that strives to develop new computing techniques through observing how naturally occurring phenomena behave to solve complex problems in various environmental situations. Brain-inspired computation is one of these techniques that covers multiple applications in very different fields. Through the International Work-Conference on the Interplay between Natural and Artificial Computation (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: neuroscience, affective computing, robotics, and deep learning.

1) Machine learning holds great promise in the development of new models and theories in the field of neuroscience, in conjunction with traditional 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 within pattern recognition and artificial intelligence, and the neuroscience community. Artificial intelligence has become the ultimate scale to test the limits of technological advances in dealing with life science challenges and needs. In this sense, the interplay between natural and artificial computation is expected to play a most relevant role in the diagnosis, monitoring, and treatment of neurodegenerative diseases, using the advanced computational solutions provided by machine learning and data science. This requires

interchanging new ideas, launching projects and contests, and, eventually, creating an inclusive knowledge-oriented network with the aim of empowering researchers, practitioners and users of technological solutions for daily life experience in the domains of neuromotor and linguistic competence functional evaluation, clinical explainability, and rehabilitation by interaction with humans, robots, and gaming avatars, not being strictly limited to only these but also open to other related fields. The use of machine learning-based precision medicine in monitoring daily life activity and providing well-being conditions to especially sensitive social sectors is one of the most relevant objectives. Case study descriptions involving neurodegenerative diseases (Alzheimer's disease, fronto-temporal dementia, cerebrovascular damage and stroke, autism, Parkinson's disease, amyotrophic lateral sclerosis, multiple sclerosis, Huntington's chorea, etc.) are included in the proceedings. Mild cognitive impairment (MCI) is considered the stage between the mental changes that are seen between normal ageing and early-stages of dementia. Indeed, MCI is one of the main indicators of incipient Alzheimer's disease (AD) among other neuropsychological diseases. The growth of these diseases is generating a great interest in the development of new effective methods for the early detection of MCI because, although no treatments are known to cure MCI, this early diagnosis would allow early intervention to delay the effects of the disease and accelerate progress towards effective treatment in its early stages. Although there have been many years of research, the early identification of cognitive impairment, as well as the differential diagnosis (to distinguish significant causes or typologies for its treatment), are problems that have been addressed from different angles but are still far from being solved. Diverse types of tests have already been developed, such as biological markers, magnetic resonance imaging, and neuropsychological tests. While effective, biological markers and magnetic resonance imaging are economically expensive, invasive, and require time to get a result, making them unsuitable as a population screening method. On the other hand, neuropsychological tests have a reliability comparable to biomarker tests, and are cheaper and quicker to interpret.

2) 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 sentiments and react accordingly. With the aim of endowing HMIs with the emotional intelligence they lack, the science of affective computing focuses on the development of artificial intelligence by means of the analysis of affects and emotions, such that systems and devices could be able to recognize, interpret, process, and simulate human sentiments.

   Nowadays, the evaluation of electrophysiological signals plays a key role in the advancement towards that purpose since they are an objective representation of the emotional state of an individual. Hence, the interest in physiological variables like electroencephalograms, electrocardiograms, 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 increase in recent years. In this sense, the 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 those media tools. For this edition, the theme of affective computing and sentiment analysis was intended to be a meeting point for researchers who are interested in any of the areas of expertise related to sentiment analysis, including those seeking to initiate their studies and those currently working on these topics. Hence, papers introducing new proposals based on the analysis of physiological measures, facial recognition, speech recognition, or natural language processing in social media are included as examples of affective computing and sentiment analysis.

3) Over the last decade there has been an increasing interest in using machine learning, and in the last few years deep learning methods, combined with other vision techniques to create autonomous systems that solve vision problems in different fields. Therefore, a special session was organized to serve researchers and developers publishing original, innovative, and state-of-the art algorithms and architectures for real-time applications in the areas of computer vision, image processing, biometrics, virtual and augmented reality, neural networks, intelligent interfaces, and biomimetic object-vision recognition.

   The aim was to provide a platform for academics, developers, and industry-related researchers belonging to the vast communities of the neural network, computational intelligence, machine Learning, deep learning, biometrics, vision systems, and robotics fields to, discuss, share, experience, and explore traditional and new areas of computer vision, machine learning, and deep learning which can be combined to solve a range of problems. The objective of the session was to integrate the growing international community of researchers working on the application of machine learning and deep learning methods in vision and robotics to facilitate a fruitful discussion on the evolution of these technologies and the benefits to society.
4) Finally, 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 to a point that only ten years ago was just science fiction. In addition, this technology has been open sourced by the main IA 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 also growing at an exponential rate. In recent years there has been an increasing interest in using machine learning methods to analyse 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 was selected to serve researchers and developers publishing original, innovative, and state-of-the art machine learning algorithms and architectures to analyse and visualize large amounts of data.

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 (a 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 between the natural and the artificial, and we face this same problem every two years, although last year we had to postpone the conference due to the COVID-19 pandemic. 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 events. The IWINAC 2022 proceedings contain the works selected by the Scientific Committee from more than 200 submissions, after the refereeing process. The first volume, entitled Artificial Intelligence in Neuroscience: Affective Analysis and Health Applications, includes all the contributions mainly related to new tools for analyzing neural data, or detecting emotional states, or interfacing with physical systems. The second volume, entitled Bioinspired Systems and Applications: from Robotics to Ambient Intelligence, contains the papers related to bioinspired programming strategies and all the contributions oriented to the computational solutions to engineering problems in different application domains, such as biomedical systems or big data solutions.

An event of the nature of IWINAC 2022 cannot be organized without the collaboration of a group of institutions and people who we would like to thank now, starting with UNED and the Universidad Politécnica de Cartagena. The collaboration of the Universidad de La Laguna (ULL) was crucial, as was the efficient work of the Local Organizing Committee, chaired by Josefa Dorta Luis and Pedro Gómez Vilda with the close collaboration of Carmen Victoria Marrero Aguilar, (UNED), Carolina Jorge Trujillo (ULL), and Chaxiraxi Díaz Cabrera (ULL). In addition to our universities, we received financial support from the Universidad de La Laguna, Ayuntamiento Puerto de la Cruz, 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 Hojjat Adeli, from Ohio State University (USA), Rafael Rebolo, from the Instituto de Astrofísica de Canarias (Spain), Manuel de Vega, from the Universidad de La Laguna (Spain), Athanasios Tsanas, from the University of Edinburgh (UK), and Luis M. Sarro, from the Universidad Nacional de Educacion a Distancia (Spain) 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, conditio 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 goes also to Springer, for the continuous receptivity, help, and collaboration in all our joint editorial ventures on the interplay between neuroscience and computation.

Finally, we want to express our special thanks to BCD Travel (formerly Viajes Hispania), our technical secretariat, and to Chari García, Ana María García, and Juani Blasco, for making this meeting possible, and for arranging all the details that comprise the organization of this kind of event.

We would like to dedicate these two volumes of the IWINAC proceedings in memory of Professor Mira.

June 2022

José Manuel Ferrández Vicente
José Ramón Álvarez-Sánchez
Félix de la Paz López
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