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PREFACE

Preface: operations research in neuroscience III

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Neuroscience is a multidisciplinary science concerned with the study of the structure and function of the nervous system. It encompasses aspects of cellular and molecular biology, physiology as well as behavioral and cognitive sciences. Newest theoretical and technological advances offer promising opportunities for a better quantitative understanding of the nervous system. Recent techniques such as optogenetics, in vitro and in vivo multielectrode recording, neuro- and brain imaging produce high-quality data that can be used to facilitate the fundamental mechanisms of information processing in our neural domains. This rapidly growing reservoir of experimental data has triggered the preparation of mathematical models that are offering novel insights into nervous system functions at various orders and scales, ranging from molecular and cellular levels to behavior and cognition. Refined analyses of intracellular signaling or dynamics in heterogeneous neural networks, conditional behavior, or connections of brain regions in decision-making lead to theoretical questions that can be addressed by Operations Research (OR).

After the encouraging and positive response by the scientific and wider community to the previous two special issues, *Operations Research for Neuroscience* and *Operations Research for Neuroscience II*, the journal *Annals of Operations Research* (*ANOR*) invited submissions of papers to this third special issue on the same subject, called *Operations Research for Neuroscience III*.

Today, we are glad to present this work to our community of science and its applications. It covers a broad range of topics, advancing the field of neuroscience as well as OR.

Among the topics discussed in this issue there are:

- *Intracellular signaling and regulation*
- *Synaptic plasticity*

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- *Dynamics in heterogeneous neural networks*
- *Intelligent systems and control, hybrid systems, and regime switching models*
- *Neuronal and neural generalized Turing machine models*
- *Perceptual, cognitive, and behavioral functions*
- *Learning and memory*
- *Spatio-temporal network analysis*
- *Behavioral economics and finance*
- *Linguistics and cognition*
- *Combinatorial optimization*
- *Signal and information processing*
- *Neuroimaging and functional brain imaging processing*
- *Computational modeling and simulation*
- *Formal theoretical approaches*
- *Foundations of analytics and artificial intelligence*, etc.

In their article "Exploring cognitive aspects of FITradeoff method using neuroscience tools", *Anderson Lucas Carneiro de Lima da Silva*, *Ana Paula Cabral Seixas Costa,* and *Adiel Teixeira de Almeida* address FITradeoff that belongs to the multiple decision support methods that have been developed to aid multi-criteria problems, offering a structured approach, and it has a strong axiomatic structure. It offers an experience with low cognitive effort and time by the decision maker. This presented method analyzes the cognitive aspects during the elicitation process. Neurological and psychophysiological data come from the use of the tools Eye-Tracker and a 14-channel EEG. Then, analyses and considerations are made about the elicitation process with FITradeoff and the impact of different types of criteria on the decision maker's performance. This can create future directions for enhanced decision support systems.

In their paper from behavioral finance, "Stochastic differential games for optimal investment problems in a Markov regime-switching jump-diffusion market", *Emel Savku* and *Gerhard-Wilhelm Weber* employ dynamic programming principle on two optimal investment problems in a continuous-time Markov regime-switching setting. They model different states of an economy and, hence, investors' floating levels of psychological reactions by a D-state Markov chain: a zero-sum game between an investor and the market, and a nonzero-sum stochastic differential portfolio game. The authors derive regime-switching Hamilton–Jacobi–Bellman–Isaacs equations, and explicit optimal portfolio strategies with Feynman–Kac representations of value functions. For a two-state special case the results are illustrated and the impact of regime switches observed by a comparison.

In their work "Use of the Alpha-Theta Diagram as a decision neuroscience tool for analyzing holistic evaluation in decision making", *Lucia Reis Peixoto Roselli* and *Adiel Teixeira de Almeida* by a neuroscience tool improve the holistic evaluation in FITradeoff decision-making, generating recommendations to support the analyst while they are advising the decision-maker. Using an electroencephalogram, Alpha and Theta activities were monitored from 27 management engineering students. The experiment consists of graphical and tabular visualizations representing multi-criteria decision problems, and presented in the holistic FITradeoff evaluation phase. An Alpha-Theta diagram is obtained. Now, visualizations are revealed in which the decision-maker presents the adequate behavioral patterns with high cognitive effort and engagement. Statistical tests show that in most visualizations there have been significant cognitive effort or engagement of participants. In the future, rigorous investigations should be performed with EEG responses.

In the article "Improving P300 Speller performance by means of optimization and machine learning", *Luigi Bianchi*, *Chiara Liti*, *Giampaolo Liuzzi*, *Veronica Piccialli,* and *Cecilia Salvatore* study Brain-Computer Interfaces (BCIs), recorded from the brain after specific events or stimuli, based on the P300 Event-Related Potentials (ERP) that are robust. Presence of a P300 evoked potential within EEG features is determined by classification. The authors improve the classification performances in P300-based BCIs by combining optimization with machine learning. First, a new decision function aims at enhancing the classification in terms of accuracy and information transfer rate. Then, a new SVM training problem facilitates the target-detection. This method proves to be effective on several public datasets.

In the paper "Designing a hybrid reinforcement learning based algorithm with application in prediction of the COVID-19 pandemic in Quebec", *Soheyl Khalilpourazari* and *Hossein Hashemi Doulabi* work on the prediction of COVID-19 for an optimized use of healthcare system capacity and resource allocation. Therefore, they design a novel hybrid reinforcement learning-based algorithm capable of solving complex optimization problems. It provides quality solutions for most complex benchmarks and is superior to state-of-the-art methods according to several measures. Applied to recent data from Quebec, Canada, to predict COVID-19, it accurately reflects the future trend with a very low mean-square error. The authors determine essential factors and provide various managerial insights for decision making, addressing future social measures.

As Guest Editors, we will be glad if the selected topics could offer a good coverage of international research dealing with the emerging and complex problems of neuroscience and its associated fields in medicine using OR. We are very thankful to *Annals of Operations Research* and the publishing house of Springer for the honor of hosting this special issue as a new and increasingly established scientific project. Particular gratitude is extended to Editor-in-Chief Dr. Endre Boros, for his interest and confidence in, and support of our special issue from the very beginning of the project to Publications Manager Ms. Ann Pulido, for her continuous advice, guidance, and support in every respect. We are thankful to all the authors for their efforts and willingness to share their newest insights with the community, and we hope that their research will stimulate collaboration and progress all over the world.

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