Guest Editorial:

~~Special Issue~~ Special Issue on Emerging Computational Intelligence Techniques for Decision Making with Big Data in Uncertain Environments

Decision making in a big-data environment poses many challenges because of the high dimensional, heterogeneous, complex, unstructured, and unpredictable characteristics of the data, which often suffer from different kinds of uncertainty. The uncertainty in the data may arise due to many factors including missing values, imprecise measurements, changes in process characteristics during the data generation period, lack of appropriate monitoring of data measurement process to name a few. Internet-of-Things (IoT) systems usually generate a large amount of unstructured and heterogeneous data demanding specialized techniques for data analytics. Thus, decision making in such an environment poses significant challenges and often demands new and innovative design techniques and algorithms for decision making.

This special issue focuses on new /emerging computational intelligence (CI) based theories and methodologies for decision making with big data under uncertain environments. The emerging CI techniques cover a broad range of nature-inspired, multidisciplinary computational methodologies, such as fuzzy logic, computing with words (fuzzy and non-fuzzy), neural networks, artificial life, evolutionary computing, cognitive computing, learning theory, probabilistic methods, their extensions, and judicious integration. The objective of this special issue is to explore how CI models and their variants can be adapted, augmented and extended to deal with applications involving very large scale data and how to cope with different kinds of difficult applications scenarios therein.

Keeping the above objectives in mind, we have selected six articles for this special issue of the *IEEE Transactions on Emerging Topics in Computational Intelligence*, that represent some of the latest developments in the emerging areas of computational intelligence techniques for decision making with big data in an uncertain environment. For the record, a total of twenty submissions were received in response to the open call. These papers were rigorously evaluated according to the normal reviewing process, which took into consideration factors pertaining to originality, technical quality, presentational quality, and overall contribution. The six articles provide a highly interesting view of the current research and potential avenues of emerging computational intelligence techniques for decision making with big data under uncertain environments. The breadth of the research captured by these articles provides an indication of the importance of computational intelligence techniques and indicates their potential for further development of theories and methodologies for decision making with big data when confronted with uncertainty.

The paper titled “Closing the Loop in Feedback Driven Learning Environments Using Trust Decision Making and Utility Theory,” by Mahmud *et al.*, proposes a novel utility theory based trust evaluation model, wherein the utility of a learning objective is computed in terms of trust applicable to big datasets. The utility is computed by allowing users to weigh the course related attributes according to their preferences. The utility value facilitates learners to select trustworthy learning objectives and enables instructors to improve different aspects of learning objectives. The results indicate that the proposed unique intelligent model is effective for dynamic and user-specified trust evaluation of learning objectives in connection with decision making under uncertainty..

The paper ntitled “An Evolutionary Model to Mine High Expected Utility Patterns from Uncertain Databases,” by Ahmed *et al.*, considers both utility and uncertainty as the majority objects to efficiently mine the interesting high expected utility patterns (HEUPs) in a limited time based on the multi-objective evolutionary framework. Authors develop a Multi-Objective Evolutionary Approach to mine High Expected Utility Pattern Mining (MOEA-HEUPM) model, which can discover the valuable HEUPs without pre-defined threshold values in an uncertain environment. Two encoding methodologies are considered in the developed MOEA-HEUPM to show its effectiveness, and the set of non-dominated HEUPs can be discovered in a limited time for decision-making. Experiments are conducted to show the effectiveness and efficiency of the designed MOEA-HEUPM

model in terms of convergence, hyper-volume and number of the discovered patterns compared to the generic approaches.

The third paper, "Consensus Learning for Distributed Fuzzy Neural Network in Big Data Environment," by Shi *et al.*, proposes a true distributed fuzzy neural network (D-FNN) model to handle the uncertainty and distributed challenges in the big data environment. The proposed D-FNN model considers consensus for both the antecedent and consequent layers. A novel consensus learning, which involves a distributed structure learning and a distributed parameter learning, is proposed to learn the D-FNN model. The proposed consensus learning algorithm is built on the well-known alternating direction method of multipliers, which does not exchange local data among agents. The primary contributions of this paper are to propose a true D-FNN model for the big data and a novel consensus learning algorithm for this D-FNN model. Experimental results on popular datasets demonstrate the superiority and effectiveness of the proposed D-FNN model and consensus learning algorithm.

The paper titled "Handling Uncertainty in Financial Decision Making: A Clustering Estimation of Distribution Algorithm with Simplified Simulation," by Shi *et al.*, considers a group insurance portfolio problem as an instance of financial optimization with strong uncertainty. They first analyze the features of the problem and discover that in such kind of optimization problem with high uncertainty, the solutions are strongly related to the scenario, and then design a simplified simulation approach. Only one scenario is simulated for each generation in the evolution process to deal with the uncertainties. They propose a new clustering estimation of distribution algorithm with simplified simulation (CEDA-SS), where the estimation of current profit is made by Monte Carlo (MC) simulation based on historical data and solutions in each generation are evaluated in the same scenario. Experimental results show that the proposed CEDA-SS is suitable for the group insurance portfolio problem in an uncertain environment.

Xu *et al.*, in their paper, "Decentralized Opportunistic Channel Access in CRNs Using Big-Data Driven Learning Algorithm," investigate the problem of distributed multiple secondary users (SUs) contending for opportunistic spectrum sensing and access in unknown cognitive radio networks. Both independent and identically distributed (i.i.d.) channel model and Markov channel model have been investigated. They propose the distributed channel sensing and access policies. Through theoretical analysis, the proposed policies are proved FOR WHAT, OPTIMAL ??with logarithmic regret asymptotic and in finite time. PLEASE CHECK THIS SENTENCE, By simulations with big data samples, the effectiveness of the proposed algorithm is verified. The proposed online learning algorithms could be well applied to multi-agent decision making based on big data in an unknown environment.

The paper, "Attention Deep Model with Multi-Scale Deep Supervision for Person Re-Identification," by Wu *et al.*, introduces an attention deep architecture with multi-scale deep supervision for Person re-identification (PReID). They contribute an inversion attention block to complement the attention block, and a novel multi-scale layer with deep supervision operator for training the backbone network. The proposed block and operator are used only for training, and discarded in the test phase. Experiments have been performed on three popular PReID datasets and results demonstrate that the proposed model significantly outperforms other competitive state-of-the-art methods. It can be well used for the purposes of decision making with big data in uncertain environments.

In summary, the six selected papers for this special issue highlight a subset of the challenging and novel applications of emerging computational intelligence theories and methodologies for decision making with big data in an uncertain environment. The guest editors would like to thank all the authors who submitted their work to the special issue, and all reviewers for their hard work in completing timely and constructive reviews. Special thanks go to the Editor-in-Chief, Prof Yew-Soon Ong, and members of the editorial team for their support during the editing process of this Special Issue. They worked closely with the guest editors to ensure excellent quality of this issue and guarantee its success.

To carry out this work, some of the Guest Editors are supported in part by the National Natural Science Foundation of China under Grant 61976120, in part by the Natural Science Foundation of Jiangsu Province under Grant BK20191445.

Weiping Ding, *Guest Editor*
Nantong University, China
dwp9988@163.com

Nikhil R. Pal, *Guest Editor*
Indian Statistical Institute, India
nrpal59@gmail.com

Chin-Teng Lin, *Guest Editor*
University of Technology Sydney, Australia
chin-teng.lin@uts.edu.au

Zehong Cao, *Guest Editor*
University of Tasmania, Australia
zhcaonctu@gmail.com

Yiu-ming Cheung, *Guest Editor*
Hong Kong Baptist University, Hong Kong, China
ymc@comp.hkbu.edu.hk

Wenjian Luo, *Guest Editor*
University of Science and Technology of China, China;
wjluo@ustc.edu.cn

Weiping Ding (M'16-SM'19) received the Ph.D. degree in Computation Application, Nanjing University of Aeronautics and Astronautics (NUAA), Nanjing, China, in 2013. He was a Visiting Scholar at University of Lethbridge(UL), Alberta, Canada, in 2011. From 2014 to 2015, He is a Postdoctoral Researcher at the Brain Research Center, National Chiao Tung University (NCTU), Hsinchu, Taiwan. In 2016, He was a Visiting Scholar at National University of Singapore (NUS), Singapore. From 2017 to 2018, he was a Visiting Professor at University of Technology Sydney (UTS), Ultimo, NSW, Australia. Now, Dr. Ding is the Chair of IEEE CIS Task Force on Granular Data Mining for Big Data. He is a member of Senior IEEE, IEEE-CIS, ACM, CCAI and Senior CCF. He is a member of Technical Committee on Soft Computing of IEEE SMCS, on Granular Computing of IEEE SMCS, and on Data Mining and Big Data Analytics of IEEE CIS. His main research directions involve data mining, granular computing, evolutionary computing, machine learning and big data analytics. He has published more than 80 research peer-reviewed journal and conference papers, including IEEE T-FS, T-NNLS, T-CYB, T-SMCS, T-BME, T-II, T-ETCI and T-ITS, etc. Dr. Ding currently serves on the Editorial Advisory Board of Knowledge-Based Systems and Editorial Board of Information Fusion, Applied Soft Computing. He serves/served as an Associate Editor of IEEE Transactions on Fuzzy Systems, Information Sciences, Swarm and Evolutionary Computation, IEEE Access and Journal of *Intelligent & Fuzzy Systems*, and Co-Editor-in-Chief of *Journal of Artificial Intelligence and System.* He is the Leading Guest Editor of Special Issues in several prestigious journals, including *IEEE Transactions on Evolutionary Computation, IEEE Transactions on Fuzzy Systems, Information Fusion, Information Sciences*. He has delivered more than 15 keynote speeches at international conferences and has co-chaired several international conferences and workshops in the area of data mining, fuzzy decision-making, and knowledge engineering.

Nikhil R. Pal (M'91–SM'00–F'05) is currently a Professor with the Electronics and Communication Sciences Unit of the Indian Statistical Institute, Calcutta, India. His current research interest includes brain science, computational intelligence, machine learning, and data mining. He was the Editor-in-Chief of the IEEE TRANSACTIONS ON FUZZY SYSTEMS for the period January 2005–December 2010. He has served/been serving on the editorial /advisory board/ steering committee of several journals including the International Journal of Approximate Reasoning, Applied Soft Computing, International Journal of Neural Systems, Fuzzy Sets, and Systems, IEEE TRANSACTIONS ON FUZZY SYSTEMS, and IEEE TRANSACTIONS ON CYBERNETICS. He is a recipient of the 2015 IEEE Computational Intelligence Society (CIS) Fuzzy Systems Pioneer Award. He has given many plenary/keynote speeches in different premier international conferences in the area of computational intelligence. He has served as the General Chair, Program Chair, and Co-Program chair of several conferences. He was a Distinguished Lecturer of the IEEE CIS (2010–2012, 2016–2018) and was a member of the Administrative Committee of the IEEE CIS (2010–2012). He has served as the Vice-President for Publications of the IEEE CIS (2013–2016) and is currently the President of the IEEE CIS (2018–2019). He is a Fellow of the National Academy of Sciences, India, Indian National Academy of Engineering, Indian National Science Academy, International Fuzzy Systems Association, and The World Academy of Sciences.

Chin-Teng Lin (S'88-M'91-SM'99-F'05) received the B.S. degree from National Chiao-Tung University (NCTU), Taiwan in 1986, and the Master and Ph.D. degree in electrical engineering from Purdue University, USA in 1989 and 1992, respectively. He is currently the Distinguished Professor of Faculty of Engineering and Information Technology, and Co-Director of Center for Artificial Intelligence, University of Technology Sydney, Australia. He is also invited as Honorary Chair Professor of Electrical and Computer Engineering, NCTU, and Honorary Professorship of University of Nottingham. Dr. Lin was elevated to be an IEEE Fellow for his contributions to biologically inspired information systems in 2005, and was elevated International Fuzzy Systems Association (IFSA) Fellow in 2012. Dr. Lin received the IEEE Fuzzy Systems Pioneer Awards in 2017. He served as the Editor-in-chief of IEEE Transactions on Fuzzy Systems from 2011 to 2016. He also served on the Board of Governors at IEEE Circuits and Systems (CAS) Society in 2005-2008, IEEE Systems, Man, Cybernetics (SMC) Society in 2003-2005, IEEE Computational Intelligence Society in 2008-2010, and Chair of IEEE Taipei Section in 2009-2010. Dr. Lin was the Distinguished Lecturer of IEEE CAS Society from 2003 to 2005 and CIS Society from 2015-2017. He serves as the Chair of IEEE CIS Distinguished Lecturer Program Committee in 2018. He served as the Deputy Editor-in-Chief of IEEE Transactions on Circuits and Systems-II in 2006-2008. Dr. Lin was the Program Chair of IEEE International Conference on Systems, Man, and Cybernetics in 2005 and General Chair of 2011 IEEE International Conference on Fuzzy Systems. Dr. Lin is the coauthor of Neural Fuzzy Systems (Prentice-Hall), and the author of Neural Fuzzy Control Systems with Structure and Parameter Learning (World Scientific). He has published more than 300 journal papers (Total Citation: 19,232, H-index: 64, i10-index: 243) in the areas of neural networks, fuzzy systems, brain computer interface, multimedia information processing, and cognitive neuro-engineering, including over 120 IEEE journal papers.

Yiu-ming Cheung

Zehong Cao (S'15-M'17) is currently a Lecturer (a.k.a. Assistant Professor) in Discipline of Information & Communication Technology (ICT), School of Technology, Environments and Design, University of Tasmania, Australia, and Honorary Research Fellow in the University of Technology Sydney (UTS), Australia. He completed the dual PhD program with the Faculty of Engineering and Information Technology, UTS, Australia, and the Institute of Electrical and Control Engineering, National Chiao Tung University (NCTU), Taiwan. He was honored as an Associate Editor of IEEE Access and as a Guest Editor of Swarm and Evolutionary Computation, and Neurocomputing. He was awarded CAMP (2018), UTS CAI Best Paper (2017), UTS FEIT Publication Award (2017), UTS President Scholarship (2015), and NCTU & Songshanhu Scholarship (2013). His research interests include signal processing, human-machine interfaces, neural computation, fuzzy systems, and neural networks.

Wenjian Luo received the BS and PhD degrees from Department of Computer Science and Technology, University of Science and Technology of China, Hefei, China, in 1998 and 2003. He is presently an Associate Professor of School of Computer Science and Technology, University of Science and Technology of China. His current research interests include computational intelligence and applications, network security and data privacy, machine learning and data mining. He has authored/co-authored about 100 referred papers on international conferences and journals, including top journals IEEE TEC, IEEE TETCI, IEEE TFS, IEEE TETC, IEEE TDSC, IEEE TIFS, IEEE TITS, IEEE TPS, and ACM TDAES. He is a senior member of IEEE, ACM, and CCF. He currently serves as an associate editor for Swarm and Evolutionary Computation Journal and Journal of Information Security and Applications, the editorial board member for Applied Soft Computing Journal, and the chair of the IEEE CIS ECTC Task Force on Artificial Immune Systems. He have served as the guest co-editor of the special issues/sections for six journals, including IEEE Transactions on Emerging Topics in Computational Intelligence (IEEE), Swarm and Evolutionary Computation (Elsevier), Genetic Programming and Evolvable Machines (Springer), Connection Science (Taylor & Francis), International Journal of Computational Intelligence and Applications (World Scientific Press), Journal of Computer Science and Technology (Chinese Science Press and Springer).