Guest Editorial Nature-Inspired Approaches for IoT and Big Data

NATURE-INSPIRED approaches have been widely used for different purposes over the last two decades and are still extensively researched, especially for complex real-world problems. Biological systems, or nature in general, serve as the source of the intelligence of nature-inspired approaches. The efficiency of nature-inspired approaches is due to their significant ability to imitate the best features of nature that evolved by natural selection over millions of years. These approaches have been successfully used for Internet of Things (IoT) and big data handling and relevant examples of these topics may be artificial neural networks (ANNs) and deep learning applications. On this basis, the main theme of this special issue (SI) addresses recent advances in the use of the nature-inspired approaches for IoT and big data problems.

We received 40 original submissions from all over the world for this SI. After a rigorous review process, ten articles were accepted and are presented in this SI. The first two articles address the use of a well-known genetic algorithm that mimics the process of Darwinian natural selection. ANN is one of the most successful nature-inspired approaches. ANNs, and particularly deep ANNs, have lately received much attention, particularly because of their successful use in helping to solve image- and video-based problems. The third and fourth articles discuss deep ANN systems that are implemented for different types of image recognition problems. The fifth and sixth articles discuss the application of the bio-inspired approaches in wireless networks. The fifth article uses ant colony optimization and the sixth article uses a biologically inspired resource allocation scheme for this purpose. The seventh, eighth, and ninth articles of this SI use nature-inspired heuristics for multiview recognition, cognitive IoT, and chain coding problems, respectively. The final article of this SI implements two-hybrid ANN systems that are coupled with two nature-inspired optimization techniques for the Internet of Medical Things problems.

This SI starts with the article titled "A nature-inspired node deployment strategy for connected confident information coverage in Industrial Internet of Things." This study adopts an evolutionary approach with multiple evolutionary mechanisms to optimize IoT node deployment, in terms of network lifetime and coverage ratio. The results show that using the proposed evolutionary computation scheme to evolve the system provides a clear advantage.

The article titled "An efficient evolutionary user interest community discovery model in dynamic social networks for Internet of people" also addresses the use of an evolutionary approach in an IoT system. The authors implement a multiobjective genetic algorithm to evolve the user interest community discovery model. The authors adopt the evolutionary algorithm for a microblogging social network that represents a dynamic network. The proposed evolutionary approach is benchmarked against other published methods and the results confirm the advantage of the evolutionary approach over other approaches.

A deep-learning-based system is used to investigate smoke detection in the article titled "Energy-efficient deep CNN for smoke detection in foggy IoT environment." In this study, for early smoke detection problems in different IoT environments, the authors propose a deep convolutional neural network (CNN) model and benchmark it against GoogleNet and AlexNet. The results are competitive and show that the discussed CNN models are promising solutions for these problems.

The article titled "Efficient image recognition and retrieval on IoT assisted energy-constrained platforms from big data repositories" also uses a well-known CNN model as a nature-inspired approach to address the challenges with big data in IoT-assisted energy-constrained devices. The proposed algorithm is a light-weight deep system and is used for image recognition. The results show that the proposed ANN-based systems outperforms previously published models.

Ant colony optimization, which mimics the foraging behavior of ants, is used in the article titled "Load-balanced data dissemination for wireless sensor networks: A nature-inspired approach." This nature-inspired approach is used to seek optimal path trees in wireless sensor networks. The proposed system in this study shows good performance as compared to other published approaches.

The article titled "Biologically inspired resource allocation for network slices in 5G-enabled Internet of Things" also addresses the use of the bio-inspired approaches in wireless networks. A bio-inspired heuristic is proposed for resource allocation in 5G-enabled IoT networks in which the bio-inspired approach is coupled with the cellular automaton model. The results clearly show the advantages of the system and demonstrate that this bio-inspired strategy works for 5G wireless networks.

The article titled "Adaptive fusion and category-level dictionary learning model for multi-view human action recognition" explores a new nature-inspired model in the IoT environment. Inspired by nature, the proposed adaptive fusion and dictionary learning model mines the latent relationships among different views for human action recognition. The performance of this approach is validated by comparing it with several well-known published models.

Digital Object Identifier 10.1109/JIOT.2019.2947754

The next article, titled "A bio-inspired solution to cluster-based distributed spectrum allocation in high-density cognitive Internet of Things" addresses a nature-inspired approach for cognitive IoT. A bio-inspired spectrum allocation solution is proposed for cluster-based architecture in order to maximize clustered throughput and to minimize communication delay. In this study, the authors use a biological mechanism first proposed by Turing in 1952 to explain the formation of patterns in biological systems. The Turing model is called reaction–diffusion, which specifically explains spatial concentration patterns using features from biological systems. This model is altered in the article so that it can modify a distributed cluster formation model in cognitive IoT.

The article titled "An innovative chain coding technique for compression based on the concept of biological reproduction: An agent-based modeling approach" uses an approach inspired by biological reproduction. The biological reproduction method is implemented in order to improve a chain coding technique for compression. In this nature-inspired and agent-based model, rabbits work as agents who consume carrots in order to qualify for reproduction.

The article titled "Dynamic adaptive network-based fuzzy inference system (D-ANFIS) for the imputation of missing data for Internet of Medical Things applications" attempts to optimize a hybrid fuzzy and neural network system using two nature-inspired approaches. This system is designed specifically to impute missing medical data in an IoT system. Two medical cases are discussed and both models are shown to be beneficial.

ACKNOWLEDGMENT

The guest editors would like to thank all reviewers, editors, and Prof. Xuemin (Sherman) Shen, the Editor-in-Chief of the IEEE INTERNET OF THINGS JOURNAL, for their continued help and support. They would also like to thank the NASA's Virtual Interchange for Nature-Inspired Exploration for facilitating content, discussions, and connections that enabled this collaborative effort through the organization of annual Biocene summits.

AMIR H. GANDOMI, *Guest Editor*
Faculty of Engineering and Information Technology
University of Technology Sydney
Ultimo, NSW 2007, Australia

MAHMOUD DANESHMAND, *Guest Editor*
School of Business
Stevens Institute of Technology
Hoboken, NJ 07030 USA

RASHMI JHA, *Guest Editor*
Electrical Engineering and Computing Systems Department
University of Cincinnati
Cincinnati, OH 45221 USA

DEVINDER KAUR, *Guest Editor*
Electrical Engineering and Computer Science Engineering
University of Toledo
Toledo, OH 43606 USA

HUANSHENG NING, *Guest Editor*
School of Computer and Communication Engineering
University of Science and Technology Beijing
Beijing 100083, China

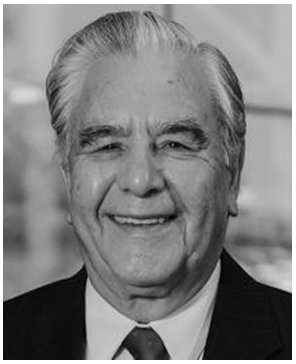
CALVIN ROBINSON, *Guest Editor*
Scientific Computing and Visualization
NASA Glenn Research Center
Cleveland, OH 44135 USA

HERB SCHILLING, *Guest Editor*
Scientific Computing and Visualization
NASA Glenn Research Center
Cleveland, OH 44135 USA

Amir H. Gandomi (GS'14–M'15–SM'19) received the Ph.D. degree in engineering from the University of Akron, Akron, OH, USA.

He was an Assistant Professor with the School of Business, Stevens Institute of Technology, Hoboken, NJ, USA; and a Distinguished Research Fellow with the BEACON Center, Michigan State University, East Lansing, MI, USA. He is a Professor of data science with the Faculty of Engineering and Information Technology, University of Technology Sydney, Ultimo, NSW, Australia. He has published over 160 journal papers and four books that collectively have been cited over 13 000 times (H-index = 56). His current research interests include global optimization and (big) data mining using machine learning and evolutionary computations in particular.

Prof. Gandomi was a recipient of the Highly Cited Researcher (top 1%) for three consecutive years, 2017 to 2019, and ranked 19th in GP bibliography among over 12 000 researchers. He has also served as an associate editor, an editor, and a guest editor in several prestigious journals and has delivered several keynote/invited talks.



Mahmoud Daneshmand (M'87–LM'15–SM'19) received the B.S. and M.S. degrees in mathematics from the University of Tehran, Tehran, Iran, and the M.S. and Ph.D. degrees in statistics from the University of California at Berkeley, Berkeley, CA, USA.

He is the Co-Founder and a Professor with the Department of Business Intelligence and Analytics; and a Professor with the Department of Computer Science, Stevens Institute of Technology, Hoboken, NJ, USA. He has over 40 years of industry and university experience as a Professor, a Researcher, an Assistant Chief Scientist, an Executive Director, the Distinguished Member of Technical Staff, the Technology Leader, the Chairman of Department, and the Dean of School with: Bell Laboratories, Murray Hill, NJ, USA; AT&T Shannon Labs-Research, Florham Park, NJ, USA; the University of California at Berkeley; the University of Texas at Austin, Austin, TX, USA; the Sharif University of Technology, Tehran; the University of Tehran; New York University, New York, NY, USA; and the Stevens Institute of Technology.

Rashmi Jha received the B.Tech. degree in electrical engineering from the Indian Institute of Technology Kharagpur, Kharagpur, India, in 2000, and the M.S. and Ph.D. degrees in electrical engineering from North Carolina State University, Raleigh, NC, USA, in 2006 and 2003, respectively.

She is an Associate Professor with the Electrical Engineering and Computer Science Department, University of Cincinnati, Cincinnati, OH, USA. She was a Process Integration Engineer for 45 nm/32 nm/22 nm High-*k*/Metal Gates-based Advanced CMOS Technologies with the Semiconductor Research and Development Center, IBM, East Fishkill, NY, USA, from 2006 to 2008. She was an Assistant Professor and then an Associate Professor with the Electrical Engineering and Computer Science Department, University of Toledo, Toledo, OH, USA, from 2008 to 2015. She has over 14 years of experience in the areas of microelectronics devices and circuits. She has been granted 12 U.S. patents and has authored/coauthored several publications. She is the Director of microelectronics and integrated-systems with the Neuro-Centric Devices (MIND) Laboratory, University of Cincinnati. Her current research interests include neuromorphic computing systems, artificial intelligence, neuromimetic devices, neuroelectronics, emerging logic and memory technologies, advanced CMOS devices, circuits and systems, and cybersecurity with hardware emphasis.

Dr. Jha was a recipient of the U.S. Airforce Summer Faculty Fellowship Award in 2017 to work in the areas of neuromorphic computing with AFRL, Rome, NY, USA; the CAREER Award from the National Science Foundation in 2013; the IBM Faculty Award in 2012; and the IBM Invention Achievement Award in 2007.

Devinder Kaur (M'89–SM'00–LM'19) received the B.Sc. and M.Sc. (Hons.) degrees in physics (majoring in electronics) from Panjab University, Chandigarh, India, in 1969 and1970, respectively, and was awarded the University Medal for obtaining the First Rank, and the M.Sc. degree in medical physics from the University of Aberdeen, Aberdeen, U.K., in 1976, under the Commonwealth Scholarship Award, and the M.Sc. degree in computer engineering and the Ph.D. degree in computer engineering from Wayne State University, Detroit, MI, USA, in 1985 and 1989, respectively.

She was a Scientist with the Central Scientific Instruments Organization, a National Lab, under the Ministry of Science and Technology, Chandigarh, India, from 1971 to 1981. In 1989, she joined the University of Toledo, Toledo, OH, USA, as a Faculty Member, where she is currently a Full Professor with the Department of Electrical Engineering and Computer Science. She has published upward of 100 papers in refereed journals and proceedings of the international conferences. Her current research interests include develop intelligent applications based on hybrid computational models using biologically inspired computing and fuzzy systems.

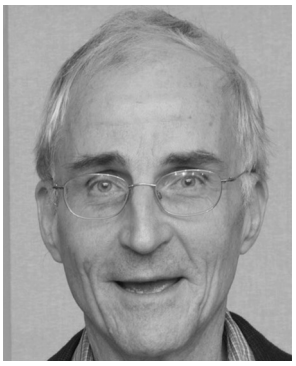
Prof. Kaur was a recipient of the IIT Delhi Fellowship from 1970 to 1971 and the Fulbright Senior Specialist Award in 2004, and visited Nippon Institute of Technology Japan in that capacity. She has worked on projects funded by NSF, AFRL, Daimler Chrysler, and ROMAN Engineering.

Huansheng Ning received the B.S. degree from Anhui University, Hefei, China, in 1996, and the Ph.D. degree from Beihang University, Beijing, China, in 2001.

He is currently a Professor and the Vice Dean of the School of Computer and Communication Engineering, University of Science and Technology Beijing, Beijing. He is the Founder of the Cyberspace and Cybermatics International Science and Technology Cooperation Base. His current research interests include Internet of Things and general cyberspace.

Calvin Robinson received the B.S. degree in computer science and engineering from the University of Toledo, Toledo, OH, USA.

He is a Computer Scientist with NASA's Glenn Research Center, Cleveland, OH, USA. Working under the Center's Scientific Computing and Visualization Team, he has a decade's worth of experience leading and supporting the development of software for several scientific disciplines. He is currently leading efforts in data management to improve tooling for curation and analysis of the center's science and engineering data. Also being an advocate of educational outreach, he has formed partnerships between his team and local libraries and schools. These partnerships have created successful computer science and data literacy programs, designed to engage and inspire future Computer and data scientists.



Herb Schilling received the B.S., M.S., and Ph.D. degrees from Case Western Reserve University, Cleveland, OH, USA, in 1979, 1980, and 1982, respectively.

He is a Computer Scientist with NASA Glenn Research Center, Cleveland, OH, USA. He serves as the Team Leader for the Scientific Computing and Visualization Team and works on a team working to apply nature-inspired solutions to NASA problems.