Nature-Inspired Approaches for IoT and Big Data

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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 and deep learning applications. On this basis, the main theme of this special issue addresses recent advances in the use of nature-inspired approaches for IoT and big data problems.

We received 40 original submissions from all over the world for this Special Issue (SI). After a rigorous review process, 10 papers were accepted and are presented in this SI. The first two papers address the use of a well-known genetic algorithm that mimics the process of Darwinian natural selection. Artificial neural network (ANN) is one of the most successful nature-inspired approaches. ANNs, and particularly deep ANN, have lately received much attention, particularly because of their successful use in helping to solve image and video-based problems. The third and fourth papers discuss deep ANN systems that are implemented for different types of image recognition problems. The fifth and sixth papers discuss the application of bio-inspired approaches in wireless networks. The fifth paper used ant colony optimisation and the sixth paper used a biologically inspired resource allocation scheme for this purpose. The seventh, eight, and ninth papers of this SI use nature-inspired heuristics for multi-view recognition, cognitive IoT, and chain coding problems, respectively. The final paper of this SI implemented two-hybrid ANN systems that are coupled with two nature-inspired optimization techniques for internet of medical things problems.

This SI starts with the paper entitled "A Nature-Inspired Node Deployment Strategy for Connected Confident Information Coverage in Industrial Internet of Things". This study adopted an evolutionary approach with multiple evolutionary mechanisms to optimise 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 provided a clear advantage.

The second paper in this SI, entitled "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 implemented a multi-objective genetic algorithm to evolve the user interest community discovery model. The authors adopted the evolutionary algorithm for a microblogging social network that represented a dynamic network. The proposed evolutionary approach was 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 third paper entitled "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 proposed a deep convolutional neural network (CNN) model and benchmarked it against GoogleNet and AlexNet. The results were competitive and showed that the discussed CNN models are promising solutions for these problems.

The paper entitled "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 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 outperformed previously published models.

Ant colony optimization, which mimics the foraging behaviour of ants, is used in the fifth paper entitled "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 showed good performance as compared to other published approaches.

The sixth paper, entitled "Biologically Inspired Resource Allocation for Network Slices in 5G-Enabled Internet of Things", also addresses the use of 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 paper entitled "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 was validated by comparing it with several well-known published models.

The next paper addresses a nature-inspired approach for cognitive IoT, entitled "A Bio-inspired Solution to Cluster-based Distributed Spectrum Allocation in High-density Cognitive Internet of Things". A bio-inspired spectrum allocation solution is proposed for cluster-based architecture in order to maximise clustered throughput and to minimise communication delay. In this study, the authors used 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 was altered in this paper so that it could modify a distributed cluster formation model in Cognitive IoT.

The paper entitled "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 last paper is entitled "Dynamic Adaptive Network-Based Fuzzy Inference System (D-ANFIS) for the imputation of missing data for Internet of Medical Things Applications". This paper 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 were shown to be beneficial.

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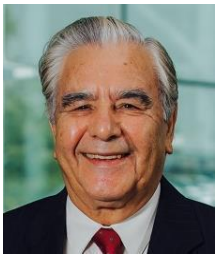

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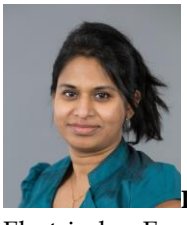

Rashmi Jha is an Associate Professor in Electrical Engineering and Computer Science Department at the University of Cincinnati. She worked as an Assistant Professor and then Associate Professor in Electrical Engineering and Computer Science Department at the University of Toledo from 2008 to 2015. Before this, she worked as a Process Integration Engineer for 45 nm/32nm/22nm High-k/Metal Gates based Advanced CMOS technologies at Semiconductor Research and Development Center, IBM, East Fishkill New York between 2006-2008. She finished her Ph.D. and M.S. in Electrical Engineering from North Carolina State University in 2006 and 2003, respectively, and B.Tech. in Electrical Engineering from Indian Institute of Technology (IIT) Kharagpur, India in 2000. She has more than 14 years of experience in the areas of Microelectronics devices and circuits. She has been granted 12 US patents and has authored/co-authored several publications. She has been a recipient of US Airforce Summer Faculty Fellowship Award in 2017 to work in the areas of Neuromorphic Computing at AFRL, Rome NY; CAREER Award from the National Science Foundation (NSF) in 2013; IBM Faculty Award in 2012; IBM Invention Achievement Award in 2007. She is the director of Microelectronics and Integrated-systems with Neuro-centric Devices (MIND) laboratory at the University of Cincinnati. Her current research interests lie in the areas of Neuromorphic Computing Systems, Artificial Intelligence, Neuromimetic Devices, Neuroelectronics, Emerging Logic and Memory Technologies, Advanced CMOS Devices, Circuits and Systems, and Cyber-Security with Hardware emphasis.

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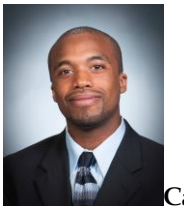

Calvin Robinson is a Computer Scientist at NASA's Glenn Research Center. Working under the Center's Scientific Computing and Visualization Team, he has a decade's worth of experience leading and supporting the development of software for several scientific disciplines. Currently, he is leading efforts 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.

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