# Guest Editorial
# Adaptive and Learning Systems

ADAPTIVE and learning systems have drawn considerable attention in the last few decades due to their inherent strength in suitably modeling many real-world complex systems, which are otherwise difficult to model using the traditional existing tools and systems. There exist many theories of adaptation and learning such as learning automata (LA), neural networks, and cellular automata. Considering the case of LA, for example, although it is only quite recently that LA and their applications in solving complex problems have become popular, their history dates back to the 1950s and 1960s with reference to the works of mathematicians and mathematical psychologists such as Bush and Mosteller, Atkinson *et al.*, Tsetlin, and Varshavskii and Vorontsova, among others. Some of the popular current-generation researchers on LA include K. Narendra, M. A. L. Thathachar, B. J. Oommen, S. Lakshmivarahan, M. S. Obaidat, K. Najim, A. S. Poznyak, N. Baba, L. G. Mason, P. S. Sastry, A. S. Pomportsis, G. Papadimitriou, S. Misra, M. R. Meybodi, and H. Beigy.

In typical LA systems, a self-operating machine or a mechanism, termed as an *Automaton*, responds to a sequence of instructions in a certain way, so as to achieve a certain goal. The Automaton either responds to a predetermined set of rules or adapts to the environmental dynamics in which it operates. The term *learning* has its root in Psychology and is used to refer to the act of acquiring knowledge and modifying one's behavior based on the experience gained. Thus, in LA, the adaptive automaton adapts to the responses from the environment through a series of interactions with it. It then attempts to learn the best action from a set of possible actions that are offered to it by the random stationary or nonstationary environment in which it operates. The Automaton thus acts as a decision-maker to arrive at the best action.

Some of the attractive features of LA such as their ability to rapidly and accurately converge and their low computational complexity have made them useful for solving problems involving network call-admission control, distributed scheduling, training hidden Markov models, neural-network adaptation, graph partitioning, intelligent vehicle control, dynamic shortest path, and pattern classification. Their advantages appear prominent in optimizing problems in which an optimal action needs to be determined from a set of actions. Typically, learning is of best help only when there are high levels of *uncertainty* in the system in which the automaton operates.

This Special Issue of IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS—PART B has attracted many papers from researchers all over the world who are currently active in research in stochastic learning systems, so that their research results can be disseminated widely for use in solving complex scientific and engineering problems faced by researchers working in different application domains. This Special Issue is the cross-pollination of ideas among LA researchers and the researchers working in different application domains, which makes it indeed "special" in the years to follow. We have accepted only 6 papers out of 18 submissions. The published papers are of high quality and represent both theoretical and application flavors. Although there are sporadic occurrences of papers in the literature relating to the theory and applications of LA and Adaptive Learning, this Special Issue will help to provide a common firm platform for researchers working in these areas to exhibit their research findings.

Horn and Oommen considered the problem of partitioning a set P of $|\mathrm{P}|$ elements (or objects) into $|\mathrm{N}|$ mutually exclusive *classes*, with the goal of having "similar" elements cluster with each other in the same class. The objects could be linked together in a multiconstraint (and possibly contradictory) manner. This was motivated and illustrated by the static-mapping problem of assigning a set of processes of a parallel application to a set of computing nodes. The literature reports solutions in which the similarity constraint consists of a *single* index inappropriate for the type of multiconstraint problems considered here and where the constraints could simultaneously be *contradictory*. Such a scenario is illustrated with the *static-mapping problem*, which consists of distributing the processes of a parallel application onto a set of computing nodes. This is a classical and yet very important problem within the areas of parallel computing, GRID computing, and *cloud* computing. The authors developed four LA-based algorithms to solve this problem. First, a fixed-structure stochastic automata algorithm where the processes try to form pairs to go onto the same node. This algorithm solves the problem, although it requires some centralized coordination. As it is desirable to avoid centralized control, the authors subsequently presented *three* different variable-structure stochastic automata (VSSA) algorithms, which have superior partitioning properties in certain settings, although they forfeit some of the scalability features of the fixed-structure algorithm. All the three VSSA algorithms model the processes as automata having, first, the hosting nodes as possible actions; second, the processes as possible actions; and third, attempting to estimate the process communication digraph prior to probabilistically mapping the processes.

Sastry, Nagendra, and Manwani presented a new formulation for noise-tolerant learning of liner classifiers using continuous-action-set LA (CALA). They considered the general case of nonuniform noise where the probability that the class label of an example is wrong may be a function of the feature vector

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of the example. In addition, the authors introduced a scheme employing a team of CALA and proved that, under certain conditions, it achieves noise-tolerant learning as long as the probabilities of wrong label for any example is lower than 0.5.

Oommen and Hashem proposed a learning scheme which is based on student–classroom interaction. Student is capable of learning not only from the teacher but also from any of his colleague students. In this way, a weak learner can utilize the information that he gets from a superior colleague, resulting in an accelerated learning process. The performance results showed that a weak learner can actually benefit from the capability of utilizing the information that he gets from a superior colleague—if this information transfer is done appropriately. The authors claimed that the whole concept of students learning from both a teacher and from a classroom of students is new.

Yeh and Tsai proposed a cerebeller model articulation controller (CMAC) control system with a single-input controller implemented by a differentiable CMAC. The proposed CMAC controller is stand-alone in the system and could be online trained by the proposed learning rules. In addition, this paper introduced the concept of the dead-zone function into the learning rule to effectively stop the CMAC learning process when the error is small and, at the same time, to allow the system to respond to any change in the reference command. To train the differentiable CMAC effectively, conditions on the learning rates guaranteeing the convergence of the output error in the sense of Lyapunov stability is also derived. The authors provided simulation results showing effectiveness for controlling three different plants.

Beigy and Meybodi introduced the concept of cellular LA (CLA), which has amalgamation of ideas of cellular automata and LA. The authors claimed that the proposed concept is superior to cellular automata in regard to learning, and as it is a collection of LA working in a collection, it has properties superior to a simple learning automaton. In addition, the authors showed that, for commutative rules, these CLA converge to a stable configuration for which the average reward for the CLA is maximum. Numerical results were also presented to confirm the theory.

Finally, Misra, Oommen, Yanamandra, and Obaidat introduced a LA-like (LAL) mechanism for congestion avoidance in wired networks. The main objective of the proposed scheme is to optimize the value of the average size of the queue used for congestion avoidance and to consequently reduce the total loss of packets at the queue. The proposed scheme, called the LA-Like Random Early Detection (LALRED), is founded on the principles of the operations of existing RED congestion-avoidance mechanisms, augmented with a LAL philosophy. The primary objective of LALRED is to optimize the value of the average size of the queue used for congestion avoidance and to consequently reduce the total loss of packets at the queue. The authors attempted to achieve this by stationing a LAL algorithm at the gateways and by discretizing the probabilities of the corresponding actions of the congestion-avoidance algorithm. At every time instant, the LAL scheme chooses the action which possesses the maximal ratio between the number of times the chosen action is rewarded and the number of times that it has been chosen. Simulation results obtained using NS2 establish the improved performance of LALRED over the traditional RED methods which were chosen as the benchmarks for performance-comparison purposes.

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He is an internationally well-known academic, researcher, and scientist. He was a Faculty Member with the City University of New York, New York. During the 2004/2005 academic years, he was on sabbatical leave as the Fulbright Distinguished Professor and Advisor to the President of Philadelphia University (Dr. A. Badran who became in April 2005 the Prime Minster of Jordan). He is currently a full Professor of computer science with Monmouth University, West Long Branch, NJ, where he was the Chair of the Department of Computer Science and the Director of the Graduate Program. He has received extensive research funding. He has authored or coauthored 8 books and over 420 refereed scholarly journal and conference articles. He has served as a Consultant for several corporations and organizations worldwide. His research interests include wireless communications and networks, Adaptive and Learning Systems, modeling and simulation, performance evaluation of computer systems and telecommunications systems, security of computer and network systems, high-performance computing/computers, applied neural networks and pattern recognition, security of e-based systems, and speech processing.

Dr. Obaidat is the Editor of many scholarly journals, including being the Editor-in-Chief of the *International Journal of Communication Systems* published by John Wiley. He is also an Editor of IEEE WIRELESS COMMUNICATIONS. In 2002, he was the Scientific Advisor for the World Bank/UN Workshop on Fostering Digital Inclusion. Recently, he was the recipient of the distinguished Nokia Research Fellowship and the Distinguished Fulbright Award. He has made pioneering and lasting contributions to the multifacet fields of computer science and engineering. He has guest-edited numerous Special Issues of scholarly journals such as IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS, IEEE WIRELESS COMMUNICATIONS, IEEE SYSTEMS JOURNAL, *Elsevier Performance Evaluation*, *SIMULATION: Transactions of Society for Computer Simulation (SCS)*, *Elsevier Computer Communications Journal, Journal of C & EE, and Wiley, Security and Communication Network Journal*, and *Wiley International Journal of Communication Systems*, among others. He has served as the Steering Committee Chair, Advisory Committee Chair, Honorary Chair, and Program Chair of many international conferences. He is the founder of the International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS) and has served as the General Chair of SPECTS since its inception. He was the recipient of a recognition certificate from IEEE. Between 1994–1997, he has served as distinguished Speaker/Visitor of the IEEE Computer Society. Since 1995, he has been serving as an Association for Computing Machinery (ACM) distinguished Lecturer. He is also an SCS Distinguished Lecturer. He is the founder of the SCS Distinguished Lecturer Program and is its current Director. Between 1996 and 1999, he served as an IEEE/ACM Program Evaluator of the Computing Sciences Accreditation Board/Commission. Between 1995 and 2002, he has served as a member of the board of directors of the Society for Computer Simulation International. Between 2002 and 2004, he has served as the Vice President of Conferences of the Society for Modeling and Simulation International SCS. Between 2004–2006, he has served as the Vice President of Membership of SCS. Between 2006–2009, he served as the Senior Vice President of SCS. He is currently the President of SCS. He has been invited to lecture and give keynote speeches worldwide. He was the recipient of the Best Paper Award on one of his recently coauthored papers in the IEEE AICCSA 2009 International Conference. In 2009, he was the recipient of the SCS prestigious McLeod Founder's Award in recognition of his outstanding technical and professional contributions to modeling and simulation. He is a Fellow of the Society for Modeling and Simulation International SCS and a Fellow of IEEE.

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Dr. Misra was the recipient of six research paper awards in different conferences. He was also the recipient of several academic awards and fellowships such as the (Canadian) Governor General's Academic Gold Medal at Carleton University and the University Outstanding Graduate Student Award in the Doctoral level at Carleton University. In 2008, he was conferred The National Academy of Sciences, India–Swarna Jayanti Puraskar. He is the Editor-in-Chief of two journals and is an Associate Editor or an Editorial Board member of a dozen others published by Elsevier, Springer, Wiley, IOS Press, etc. He is an Editor of six books in the areas of wireless ad hoc networks, wireless sensor networks, wireless mesh networks, communication networks and distributed systems, network reliability and fault tolerance, and information and coding theory, published by reputed publishers such as Springer and World Scientific. He was invited to chair several international conference/workshop programs and sessions. He was also invited to deliver keynote lectures in over 15 international conferences in the U.S., Canada, Europe, Asia, and Africa.

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