Yongduan Song, *Chongqing University, CHINA*
Jon Garibaldi, *University of Nottingham, UK*
Carlos A. Coello Coello, *CINVESTAV-IPN, MEXICO*
Georgios N. Yannakakis, *University of Malta, MALTA*
Huajin Tang, *Zhejiang University, CHINA*
Yew Soon Ong, *Nanyang Technological University, SINGAPORE*
Hussein Abbass, *University of New South Wales, AUSTRALIA*

CIS Publication Spotlight

IEEE Transactions on Neural Networks and Learning Systems

A Survey of Stochastic Computing Neural Networks for Machine Learning Applications, by Y. Liu, S. Liu, Y. Wang, F. Lombardi, and J. Han, *IEEE Transactions on Neural Networks and Learning Systems*, Vol. 32, No. 7, July 2021, pp. 2809–2824.

Digital Object Identifier: 10.1109/TNNLS.2020.3009047

"Neural networks (NNs) are effective machine learning models that require significant hardware and energy consumption in their computing process. To implement NNs, stochastic computing (SC) has been proposed to achieve a tradeoff between hardware efficiency and computing performance. In an SC NN, hardware requirements and power consumption are significantly reduced by moderately sacrificing the inference accuracy and computation speed. With recent developments in SC techniques, however, the performance of SC NNs has substantially been improved, making it comparable with conventional binary designs yet by utilizing less hardware. In this article, we begin with the design of a basic SC neuron and then survey different types of SC NNs, including multilayer perceptrons, deep belief networks, convolutional NNs, and recurrent NNs. Recent progress in SC designs that further improve the hardware efficiency and performance of NNs is subsequently discussed. The generality and versatility of SC NNs are illustrated for both the training and inference processes. Finally, the advantages and challenges of SC NNs are discussed with respect to binary counterparts."

Deep Learning for LiDAR Point Clouds in Autonomous Driving: A Review, by Y. Li, L. Ma, Z. Zhong, F. Liu, M.A. Chapman, D. Cao, and J. Li, *IEEE Transactions on Neural Networks and Learning Systems*, Vol. 32, No. 8, August 2021, pp. 3412–3432.

Digital Object Identifier: 10.1109/TNNLS.2020.3015992

"Recently, the advancement of deep learning (DL) in discriminative feature learning from 3-D LiDAR data has led to rapid development in the field of autonomous driving. However, automated processing uneven, unstructured, noisy, and massive 3-D point clouds are a challenging and tedious task. In this article, we provide a systematic review of existing compelling DL architectures applied in LiDAR point clouds, detailing for specific tasks in autonomous driving, such as segmentation, detection, and classification. Although several published research articles focus on specific topics in computer vision for autonomous vehicles, to date, no general survey on DL applied in LiDAR point clouds for autonomous vehicles exists. Thus, the goal of this article is to narrow the gap in this topic. More than 140 key contributions in the recent five years are summarized in this survey, including the milestone 3-D deep architectures, the remarkable DL applications in 3-D semantic segmentation, object detection, and classification; specific data sets, evaluation metrics, and the state-of-the-art performance. Finally, we conclude the remaining challenges and future researches."

IEEE Transactions on Fuzzy Systems

Explaining Deep Learning Models Through Rule-Based Approximation and Visualization, by E. Soares, P. P. Angelov, B. Costa, M. P. G. Castro, S. Nageshrao, and D. Filev, *IEEE Transactions on Fuzzy Systems*, Vol. 29, No. 8, August 2021, pp. 2399–2407.

Digital Object Identifier: 10.1109/TFUZZ.2020.2999776

"This article describes a novel approach to the problem of developing explainable machine learning models. We consider a deep reinforcement learning (DRL) model representing a highway path planning policy for autonomous highway driving. The model constitutes

Digital Object Identifier 10.1109/MCI.2021.3129952
Date of current version: 12 January 2022

a mapping from the continuous multidimensional state space characterizing vehicle positions and velocities to a discrete set of actions in longitudinal and lateral direction. It is obtained by applying a customized version of the double deep Q-network learning algorithm. The main idea is to approximate the DRL model with a set of IF–THEN rules that provide an alternative interpretable model, which is further enhanced by visualizing the rules. This concept is rationalized by the universal approximation properties of the rule-based models with fuzzy predicates. The proposed approach includes a learning engine composed of zero-order fuzzy rules, which generalize locally around the prototypes by using multivariate function models. The adjacent (in the data space) prototypes, which correspond to the same action, are further grouped and merged into the so-called MegaClouds reducing significantly the number of fuzzy rules. The input selection method is based on ranking the density of the individual inputs. Experimental results show that the specific DRL agent can be interpreted by approximating with families of rules of different granularity. The method is computationally efficient and can be potentially extended to addressing the explainability of the broader set of fully connected deep neural network models."

A Generalized Fuzzy Extension Principle and Its Application to Information Fusion, by M. A. Islam, D. T. Anderson, T. C. Havens, and J. E. Ball, *IEEE Transactions on Fuzzy Systems*, Vol. 29, No. 9, September 2021, pp. 2726–2738.

Digital Object Identifier: 10.1109/TFUZZ.2020.3006574

"Zadeh's extension principle (ZEP) is a fundamental concept in fuzzy set (FS) theory that enables crisp mathematical operation on FSs. A well-known short-coming of ZEP is that the height of the output FS is determined by the lowest height of the input FSs. In this article, we introduce a generalized extension principle (GEP) that eliminates this weakness and provides flexibility and control over how membership values are mapped from input to output. Furthermore, we provide a computationally efficient point-based FS representation. In light of our new definition, we discuss two approaches to perform aggregation of FSs using the Choquet integral. The resultant integrals generalize prior work and lay a foundation for future extensions. Last, we demonstrate the extended integrals via a combination of synthetic and real-world examples."

IEEE Transactions on Evolutionary Computation

Fast Immune System-Inspired Hypermutation Operators for Combinatorial Optimizations, by D. Corus, P. S. Oliveto, and D. Yazdani, *IEEE Transactions on Evolutionary Computation*, Vol. 25, No. 5, October 2021, pp. 956–970.

Digital Object Identifier: 10.1109/TEVC.2021.3068574

"Various studies have shown that immune system-inspired hypermutation operators can allow artificial immune systems (AIS) to be very efficient at escaping local optima of multimodal optimization problems. However, this efficiency comes at the expense of considerably slower runtimes during the exploitation phase compared to the standard evolutionary algorithms. We propose modifications to the traditional hypermutations with mutation potential (HMP) that allow them to be efficient at exploitation, as well as maintaining their effective explorative characteristics. Rather than deterministically evaluating fitness after each bit-flip of a hypermutation, we sample the fitness function stochastically with a "parabolic" distribution. This allows the stop at the first constructive mutation (FCM) variant of HMP to reduce the linear amount of wasted function evaluations when no improvement is found to a constant. The stochastic distribution also allows the removal of the FCM mechanism altogether as originally desired in the design of the HMP operators. We rigorously prove the effectiveness of the proposed operators for all the benchmark functions, where the performance of HMP is rigorously understood in the literature. We validate the gained insights to show linear speed-ups for the identification of high-quality approximate solutions to classical NP-Hard problems from combinatorial optimization. We then show the superiority of the HMP operators to the traditional ones in an analysis of the complete standard Opt-IA AIS, where the stochastic evaluation scheme allows HMP and aging operators to work in harmony. Through a comparative performance study of other "fast mutation" operators from the literature, we conclude that a power-law distribution for the parabolic evaluation scheme is the best compromise in black-box scenarios, where little problem knowledge is available."

IEEE Transactions on Games

More Trees or Larger Trees: Parallelizing Monte Carlo Tree Search, by E. Steinmetz and M. Gini, *IEEE Transactions on Games*, Vol. 13, No. 3, September 2021, pp. 315–320.

Digital Object Identifier: 10.1109/TG.2020.3048331

"Monte Carlo tree search (MCTS) is being effectively used in many domains, but acquiring good results from building larger trees takes time that can in many cases be impractical. In this article, we show that parallelizing the tree building process using multiple independent trees (root parallelization) can improve results when limited time is available, and compare these results to other parallelization techniques and to results obtained from running for an extended time. We obtained our results using MCTS in the domain of computer Go, which has the most mature implementations. Compared to previous studies, our results are more precise and statistically significant."

IEEE Transactions on Cognitive and Developmental Systems

Explanation as a Social Practice: Toward a Conceptual Framework for the Social Design of AI Systems, by K. J. Rohlfing, P. Cimiano, I. Scharlau, T. Matzner, H. M. Buhl, H. Buschmeier, E. Esposito, A. Grimminger, B. Hammer, R. Häb-Umbach, I. Horwath, E. Hüllermeier, F. Kern, S. Kopp, K. Thommes, A.-C. Ngonga Ngomo, C. Schulte, H. Wachsmuth, P. Wagner, and B. Wrede, *IEEE Transactions on Cognitive and Developmental Systems,* Vol. 13, No. 3, September 2021, pp. 717–728.

Digital Object Identifier: 10.1109/TCDS.2020.3044366

"The recent surge of interest in explainability in artificial intelligence (XAI) is propelled by not only technological advancements in machine learning but also by regulatory initiatives to foster transparency in algorithmic decision making. In this article, we revise the current concept of explainability and identify three limitations: passive explainee, narrow view on the social process, and undifferentiated assessment of explainee's understanding. In order to overcome these limitations, we present explanation as a social practice in which explainer and explainee co-construct understanding on the microlevel. We view the co-construction on a microlevel as embedded into a macrolevel, yielding expectations concerning, e.g., social roles or partner models: typically, the role of the explainer is to provide an explanation and to adapt it to the current level of explainee's understanding; the explainee, in turn, is expected to provide cues that direct the explainer. Building on explanations being a social practice, we present a conceptual framework that aims to guide future research in XAI. The framework relies on the key concepts of monitoring and scaffolding to capture the development of interaction. We relate our conceptual framework and our new perspective on explaining to transparency and autonomy as objectives considered for XAI."

IEEE Transactions on Emerging Topics in Computational Intelligence

Realizing Behavior Level Associative Memory Learning Through Three-Dimensional Memristor-Based Neuromorphic Circuits, by H. An, Q. An, and Y. Yi, *IEEE Transactions on Emerging Topics in Computational Intelligence*, Vol. 5, No. 4, August 2021, pp. 668–678.

Digital Object Identifier: 10.1109/TETCI.2019.2921787

"Associative memory is a widespread self-learning method in biological livings, which enables the nervous system to remember the relationship between two concurrent events. The significance of rebuilding associative memory at a behavior level is not only to reveal a way of designing a brain-like self-learning neuromorphic system but also to explore a method of comprehending the learning mechanism of a nervous system. In this paper, an associative memory learning at a behavior level is realized that successfully associates concurrent visual and auditory information together (pronunciation and image of digits). The task is achieved by associating the large-scale artificial neural networks (ANNs) together instead of relating multiple analog signals. In this way, the information carried and preprocessed by these ANNs can be associated. A neuron has been designed, named signal intensity encoding neurons (SIENs), to encode the output data of the ANNs into the magnitude and frequency of the analog spiking signals. Then, the spiking signals are correlated together with an associative neural network, implemented with a three-dimensional (3-D) memristor array. Furthermore, the selector devices in the traditional memristor cells limiting the design area have been avoided by our novel memristor weight updating scheme. With the novel SIENs, the 3-D memristive synapse, and the proposed memristor weight updating scheme, the simulation results demonstrate that our proposed associative memory learning method and the corresponding circuit implementations successfully associate the pronunciation and image of digits together, which mimics a human-like associative memory learning behavior."

IEEE Transactions on Artificial Intelligence

Learn2Evade: Learning-Based Generative Model for Evading PDF Malware Classifiers, by H. Bae, Y. Lee, Y. Kim, U. Hwang, S. Yoon, and Y. Paek, *IEEE Transactions on Artificial Intelligence*, Vol. 2, No. 4, August 2021, pp. 299–313.

Digital Object Identifier: 10.1109/TAI.2021.3103139

"Recent research has shown that a small perturbation to an input may forcibly change the prediction of a machine learning (ML) model. Such variants are commonly referred to as adversarial examples. Early studies have focused mostly on ML models for image processing and expanded to other applications, including those for malware classification. In this article, we focus on the problem of finding adversarial examples against ML-based portable document format (PDF) malware classifiers. We deem that our problem is more challenging than those against ML models for image processing because of the highly complex data structure of PDF and of an additional constraint that the generated PDF should exhibit malicious behavior. To resolve our problem, we propose a variant of generative adversarial networks that generate evasive variant PDF malware (without any crash), which can be classified as benign by various existing classifiers yet maintaining the original malicious behavior. Our model exploits the target classifier as the second discriminator to rapidly generate an evasive variant PDF with our new feature selection process that includes unique features extracted from malicious PDF files. We evaluate our technique against three representative PDF malware classifiers (Hidost'13, Hidost'16, and PDFrate-v2) and further examine its effectiveness with AntiVirus engines from VirusTotal. To the best of our knowledge, our work is the first to analyze the performance against the commercial AntiVirus engines. Our model finds, with great speed, evasive variants for all selected seeds against state-of-the-art PDF malware classifiers and raises a serious security concern in the presence of adversaries."