Publication Spotlight

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CIS Publication Spotlight

IEEE Transactions on Neural Networks and Learning Systems

A Survey on Learning-Based Approaches for Modeling and Classification of Human–Machine Dialog Systems, by F. Cui, Q. Cui, and Y. Song, *IEEE Transactions on Neural Networks and Learning Systems*, Vol. 32, No. 4, April 2021, pp. 1418–1432.

Digital Object Identifier: 10.1109/TNNLS.2020.2985588

"With the rapid development from traditional machine learning (ML) to deep learning (DL) and reinforcement learning (RL), dialog system equipped with learning mechanism has become the most effective solution to address human–machine interaction problems. The purpose of this article is to provide a comprehensive survey on learning-based human–machine dialog systems with a focus on the various dialog models. More specifically, we first introduce the fundamental process of establishing a dialog model. Second, we examine the features and classifications of the system dialog model, expound some representative models, and also compare the advantages and disadvantages of different dialog models. Third, we comb the commonly used database and evaluation metrics of the dialog model. Furthermore, the evaluation metrics of these dialog models are analyzed in detail. Finally, we briefly analyze the existing issues and point out the potential future direction on the human–machine dialog systems."

Numerical Spiking Neural P Systems, by T. Wu, L. Pan, Q. Yu, and K. C. Tan, *IEEE Transactions on Neural Networks and Learning Systems*, Vol. 32, No. 6, June 2021, pp. 2443–2457.

Digital Object Identifier: 10.1109/TNNLS.2020.3005538

"Spiking neural P (SN P) systems are a class of discrete neuron-inspired computation models, where information is encoded by the numbers of spikes in neurons and the timing of spikes. However, due to the discontinuous nature of the integrate-and-fire behavior of neurons and the symbolic representation of information, SN P systems are incompatible with the gradient descent-based training algorithms, such as the backpropagation algorithm, and lack the capability of processing the numerical representation of information. In this work, motivated by the numerical nature of numerical P (NP) systems in the area of membrane computing, a novel class of SN P systems is proposed, called numerical SN P (NSN P) systems. More precisely, information is encoded by the values of variables, and the integrate-and-fire way of neurons and the distribution of produced values are described by continuous production functions. The computation power of NSN P systems is investigated. We prove that NSN P is Turing universal as number generating devices, where the production functions in each neuron are linear functions, each involving at most one variable; as number accepting devices, NSN P systems are proved to be universal as well, even if each neuron contains only one production function. These results show that even if a single neuron is simple in the sense that it contains one or two production functions and the production functions in each neuron are linear functions with one variable, a network of simple neurons are still computationally powerful. With the powerful computation power and the characteristic of continuous production functions, developing learning algorithms for NSN P systems is potentially exploitable."

IEEE Transactions on Fuzzy Systems

Soft Overlapping Community Detection in Large-Scale Networks via Fast Fuzzy Modularity Maximization, by S. Yazdanparast, T.C. Havens, and M. Jamalabdollahi, *IEEE Transactions on Fuzzy Systems*, Vol. 29, No. 6, June 2021, pp. 1533–1543.

Digital Object Identifier: 10.1109/TFUZZ.2020.2980502

"Soft overlapping clustering is one of the notable problems of community detection. Extensive research has been conducted to develop efficient methods for nonoverlapping and crisp-overlapping community detection in large-scale networks. In this article, fast fuzzy modularity maximization (FFMM) for soft overlapping community detection is proposed. FFMM exploits novel iterative equations to calculate the

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modularity gain associated with changing the fuzzy membership values of network vertices. The simplicity of the proposed scheme enables efficient modifications, reducing computational complexity to a linear function of the network size, and the number of communities. Moreover, to further reduce the complexity of FFMM for very large networks, multicycle FFMM (McFFMM) is proposed. The proposed McFFMM reduces complexity by breaking networks into multiple subnetworks and applying FFMM to detect their communities. Performance of the proposed techniques is demonstrated with real- world data and the Lancichinetti–Fortunato–Radicchi benchmark networks. Moreover, the performance of the proposed techniques is evaluated versus some state-of-the-art soft overlapping community detection approaches. Results show that the McFFMM produces a remarkable performance in terms of overlapping modularity with fuzzy memberships, computational time, number of detected overlapping nodes, and overlapping normalized mutual information."

Fuzzy Density Peaks Clustering, by Z. Bian, F-L. Chung, and S. Wang, *IEEE Transactions on Fuzzy Systems*, Vol. 29, No. 7, July 2021, pp. 1725–1738.

Digital Object Identifier: 10.1109/TFUZZ.2020.2985004

"As an exemplar-based clustering method, the well-known density peaks clustering (DPC) heavily depends on the computation of kernel-based density peaks, which incurs two issues: first, whether kernel-based density can facilitate a large variety of data well, including cases where ambiguity and uncertainty of the assignment of the data points to their clusters may exist, and second, whether the concept of density peaks can be interpreted and manipulated from the perspective of soft partitions (e.g., fuzzy partitions) to achieve enhanced clustering performance. In this article, in order to provide flexible adaptability for tackling ambiguity and uncertainty in clustering, a new concept of fuzzy peaks is proposed to express the density of a data point as the fuzzy- operator-based coupling of the fuzzy distances between a data point and its neighbors. As a fuzzy variant of DPC, a novel fuzzy density peaks clustering (FDPC) method FDPC based on fuzzy operators (especially S-norm operators) is accordingly devised along with the same algorithmic framework of DPC. With an appropriate choice of a fuzzy operator with its associated tunable parameter for a clustering task, FDPC can indeed inherit the advantage of fuzzy partitions and simultaneously provide flexibility in enhancing clustering performance. The experimental results on both synthetic and real data sets demonstrate that the proposed method outperforms or at least remains comparable to the comparative methods in clustering performance by choosing appropriate parameters in most cases."

IEEE Transactions on Evolutionary Computation

SAFE: Scale-Adaptive Fitness Evaluation Method for Expensive Optimization Problems, by S.-H. Wu, Z.-H. Zhan, and J. Zhang, *IEEE Transactions on Evolutionary Computation*, Vol. 25, No. 3, June 2021, pp. 478–491.

Digital Object Identifier: 10.1109/TEVC.2021.3051608

"The key challenge of expensive optimization problems (EOP) is that evaluating the true fitness value of the solution is computationally expensive. A common method to deal with this issue is to seek for a less expensive surrogate model to replace the original expensive objective function. However, this method also brings in model approximation error. To efficiently solve the EOP, a novel scale-adaptive fitness evaluation (SAFE) method is proposed in this article to directly evaluate the true fitness value of the solution on the original objective function. To reduce the computational cost, the SAFE method uses a set of evaluation methods (EM) with different accuracy scales to cooperatively complete the fitness evaluation process. The basic idea is to adopt the low-accuracy scale EM to fast locate promising regions and utilize the high-accuracy scale EM to refine the solution accuracy. To this aim, two EM switch strategies are proposed in the SAFE method to adaptively control the multiple EMs according to different evolutionary stages and search requirements. Moreover, a neighbor best-based evaluation (NBE) strategy is also put forward to evaluate the solution according to its nearest high-quality evaluated solution, which can further reduce computational cost. Extensive experiments are carried out on the case study of crowdshipping scheduling problem in the smart city to verify the effectiveness and efficiency of the proposed SAFE method, and to investigate the effects of the two EM switch strategies and the NBE strategy. Experimental results show that the proposed SAFE method achieves better solution quality than some baseline and state-of-the-art algorithms, indicating an efficient method for solving EOP with a better balance between solution accuracy and computational cost."

IEEE Transactions on Games

On the Robustness of Stealth Assessment, by K. Georgiadis, G. van Lankveld, K. Bahreini, and W. Westera, *IEEE Transactions on Games*, Vol. 13, No. 2, June 2021, pp. 180–192.

Digital Object Identifier: 10.1109/TG.2020.3020015

"Stealth assessment is a methodology that utilizes machine learning (ML) for processing unobtrusively collected data from serious games to produce inferences regarding learners' mastery level. Although stealth assessment can produce valid and reliable assessments, its robustness over a wide a range of conditions has not been examined yet. The main reason is its complex, laborious, and time-consuming practical application. Therefore, its exposure to different conditions has been limited, as well as its wider uptake from the

serious game community. Nevertheless, a framework for developing a generic tool has been proposed to lift its barriers. In this article, a generic stealth assessment (SA) software tool was developed based on this framework to examine the robustness of the stealth assessment methodology under various conditions. In specific, the conditions relate to processing data sets of different distribution types and sizes (960 data sets containing a total of 72.336.000 data points are used for this reason), utilizing two different ML algorithms (Gaussian Naïve Bayes Network and C4.5), and using statistical models relating to two different competency constructs. Results show that stealth assessment is a robust methodology, whilst the generic SA tool is a highly accurate tool capable of handling efficiently a wide range of conditions."

IEEE Transactions on Cognitive and Developmental Systems

Intrinsically Motivated Hierarchical Policy Learning in Multiobjective Markov Decision Processes, by S. Abdelfattah, K. Merrick, and J. Hu, *IEEE Transactions on Cognitive and Developmental Systems*, Vol. 13, No. 2, June 2021, pp. 262–273.

Digital Object Identifier: 10.1109/TCDS.2019.2948025

"The multiobjective Markov decision processes (MOMDPs) are sequential decision-making problems that involve multiple conflicting reward functions that cannot be optimized simultaneously without a compromise. This type of problem cannot be solved by a single optimal policy as in the conventional case. Alternatively, multiobjective reinforcement learning (RL) methods evolve a coverage set of optimal policies that can satisfy all possible preferences in solving the problem. However, many of these methods cannot generalize their coverage sets to work in the nonstationary environments. In these environments, the parameters of the state transition and reward distribution vary over time. This limitation results in significant performance degradation for the evolved policy sets. In order to overcome this limitation, there is a need to learn a generic skillset that can bootstrap the evolution of the policy coverage set for each shift in the environment dynamics, therefore, it can facilitate a continuous learning process. In this article, intrinsically motivated RL (IMRL) has been successfully deployed to evolve generic skillsets for learning hierarchical policy to solve the MOMDPs. We propose a novel dual-phase IMRL method to address this limitation. In the first phase, a generic set of skills is learned, while in the second phase, this set is used to bootstrap policy coverage sets for each shift in the environment dynamics. We show experimentally that the proposed method significantly outperforms the state-of-the-art multiobjective reinforcement methods on a dynamic robotics environment."

IEEE Transactions on Emerging Topics in Computational Intelligence

Training Deep Photonic Convolutional Neural Networks with Sinusoidal Activations, by N. Passalis, G. M. Alexandris, A. Tsakyridis, N. Pleros, and A. Tefas, *IEEE Transactions on Emerging Topics in Computational Intelligence*, Vol. 5, No. 3, June 2021, pp. 384–393.

Digital Object Identifier: 10.1109/TETCI.2019.2923001

"Deep learning (DL) has achieved state-of-the-art performance in many challenging problems. However, DL requires powerful hardware for both training and deployment, increasing the cost and energy requirements and rendering large-scale applications especially difficult. Recognizing these difficulties, several neuromorphic hardware solutions have been proposed, including photonic hardware that can process information close to the speed of light and can benefit from the enormous bandwidth available on photonic systems. However, the effect of using these photonic-based neuromorphic architectures, which impose additional constraints that are not usually considered when training DL models, is not yet fully understood and studied. The main contribution of this paper is an extensive study on the feasibility of training deep neural networks that can be deployed on photonic hardware that employ sinusoidal activation elements, along with the development of methods that allow for successfully training these networks, while taking into account the physical limitations of the employed hardware. Different DL architectures and four datasets of varying complexity were used for extensively evaluating the proposed method."

IEEE Transactions on Artificial Intelligence

Privacy and Artificial Intelligence, by J. Curzon, T. Kosa, R. Akalu, and K. El-Khatib, *IEEE Transactions on Artificial Intelligence*, Vol. 2, No. 2, Apr 2021.

Digital Object Identifier: 10.1109/TAI.2021.3088084

"While an appreciation of the privacy risks associated with artificial intelligence is important, a thorough understanding of the assortment of different technologies that comprise artificial intelligence better prepares those implementing such systems in assessing privacy impacts. This can be achieved through the independent consideration of each constituent of an artificially intelligent system and its interactions. Under individual consideration, privacy-enhancing tools can be applied in a targeted manner to reduce the risk associated with specific components of an artificially intelligent system. A generalized North American approach to assess privacy risks in such systems is proposed that will retain applicability as the field of research evolves and can be adapted to account for various sociopolitical influences. With such an approach, privacy risks in artificial intelligent systems can be well understood, measured, and reduced."