Publication Spotlight

Haibo He, Jon Garibaldi, Kay Chen Tan, Julian Togelius, Yaochu Jin, and Yew Soon Ong

CIS Publication Spotlight

IEEE Transactions on Neural Networks and Learning Systems

Continuous Dropout, by X. Shen, X. Tian, T. Liu, F. Xu, and D. Tao, *IEEE Transactions on Neural Networks and Learning Systems*, Vol. 29, No. 9, September 2018, pp. 3926-3937.

Digital Object Identifier: 10.1109/TNNLS.2017.2750679

"Dropout has been proven to be an effective algorithm for training robust deep networks because of its ability to prevent overfitting by avoiding the co-adaptation of feature detectors. Current explanations of dropout include bagging, naive Bayes, regularization, and sex in evolution. According to the activation patterns of neurons in the human brain, when faced with different situations, the firing rates of neurons are random and continuous, not binary as current dropout does. Inspired by this phenomenon, we extend the traditional binary dropout to continuous dropout. On the one hand, continuous dropout is considerably closer to the activation characteristics of neurons in the human brain than traditional binary dropout. On the other hand, we demonstrate that continuous dropout has the property of avoiding the co-adaptation of feature detectors, which suggests that we can extract more independent feature detectors for model averaging in the test stage. We introduce the proposed continuous dropout to a feedforward neural network and comprehensively compare it with binary dropout, adaptive dropout, and DropConnect on Modified National Institute of Standards and Technology, Canadian Institute for Advanced Research-10, Street View House Numbers, NORB, and ImageNet large scale visual recognition competition-12. Thorough experiments demonstrate that our method performs better in preventing the co-adaptation of feature detectors and improves test performance."

Cost-Sensitive Learning of Deep Feature Representations From Imbalanced Data, by S. H. Khan, M. Hayat, M. Bennamoun, F. A. Sohel, and R. Togneri, *IEEE Transactions on Neural Networks and Learning Systems*, Vol. 29, No. 8, August 2018, pp. 3573-3587.

Digital Object Identifier: 10.1109/TNNLS.2017.2732482

"Class imbalance is a common problem in the case of real-world object detection and classification tasks. Data of some classes are abundant, making them an overrepresented majority, and data of other classes are scarce, making them an underrepresented minority. This imbalance makes it challenging for a classifier to appropriately learn the discriminating boundaries of the majority and minority classes. In this paper, we propose a cost-sensitive (CoSen) deep neural network, which can automatically learn robust feature representations for both the majority and minority classes. During training, our learning procedure jointly optimizes the class-dependent costs and the neural network parameters. The proposed approach is applicable to both binary and multiclass problems without any modification. Moreover, as opposed to data-level approaches, we do not alter the original data distribution, which results in a lower computational cost during the training process. We report the results of our experiments on six major image classification data sets and show that the proposed approach significantly outperforms the baseline algorithms. Comparisons with popular data sampling techniques and CoSen classifiers demonstrate the superior performance of our proposed method."

IEEE Transactions on Fuzzy Systems

Data-Driven Elastic Fuzzy Logic System Modeling: Constructing a Concise System With Human-Like Inference Mechanism, by J. Zhang, Z. Deng, K.-S. Choi, and S. Wang, *IEEE Transactions on Fuzzy Systems*, Vol. 26, No. 4, August 2018, pp. 2160-2173.

Digital Object Identifier: 10.1109/TFUZZ.2017.2767025

"The construction of fuzzy logic systems (FLSs) using data-driven techniques has become the most popular modeling approach. However, this approach still faces critical challenges, including the difficulty in obtaining concise models for high-dimensional data and generating accurate fuzzy rules to simulate human inference mechanism. To tackle these issues, a new FLS modeling framework called data-driven elastic FLS (DD-EFLS) is proposed in

Digital Object Identifier 10.1109/MCI.2018.2881780
Date of publication: 10 January 2019

this paper. The DD-EFLS has two key characteristics. First, the fuzzy rules in the rule base can use different feature subspaces that are extracted from the original high-dimensional space to yield simple and accurate rules in feature spaces of lower dimensionality. Second, fuzzy inferences from various views are implemented by embedding different rules in the corresponding subspaces to imitate human inference mechanism. Based on the DD-EFLS framework, an elastic Takagi-Sugeno-Kang (TSK) FLS modeling method (ETSK-FLS) is proposed to train the elastic TSK FLS using the concise rules and a more human-like inference mechanism for modeling tasks based on high-dimensional datasets. The characteristics and advantages of the proposed framework and the ETSK-FLS method are validated experimentally using both synthetic and real-world datasets."

IEEE Transactions on Evolutionary Computation

Transfer Learning-Based Dynamic Multiobjective Optimization Algorithms, by M. Jiang, Z. Huang, L. Qiu, W. Huang, and G. G. Yen, *IEEE Transactions on Evolutionary Computation*, Vol. 22, No. 4, August 2018, pp. 501-514.

Digital Object Identifier: 10.1109/TEVC.2017.2771451

"One of the major distinguishing features of the dynamic multiobjective optimization problems (DMOPs) is that optimization objectives will change over time, thus tracking the varying Pareto-optimal front becomes a challenge. One of the promising solutions is reusing "experiences" to construct a prediction model via statistical machine learning approaches. However, most existing methods neglect the nonindependent and identically distributed nature of data to construct the prediction model. In this paper, the authors propose an algorithmic framework, called transfer learning-based dynamic multiobjective evolutionary algorithm (EA), which integrates transfer learning and population-based EAs to solve the DMOPs. This approach exploits the transfer learning technique as a tool to generate an effective initial population pool via reusing past experience to speed up the evolutionary process, and at the same time any population-based multiobjective algorithms can benefit from this integration without any extensive modifications. To verify this idea, the authors incorporate the proposed approach into the development of three well-known EAs, nondominated sorting genetic algorithm II, multiobjective particle swarm optimization, and the regularity model-based multiobjective estimation of distribution algorithm. The authors employ 12 benchmark functions to test these algorithms as well as to compare them with some chosen state-of-the-art designs. The experimental results confirm the effectiveness of the proposed design for DMOPs."

IEEE Transactions on Games

Pac-Man Conquers Academia: Two Decades of Research Using a Classic Arcade Game, by P. Rohlfshagen, J. Liu, D. Perez-Liebana, and S. M. Lucas, *IEEE Transactions on Games,* Vol. 10, No. 3, September 2018, pp. 233-256.

Digital Object Identifier: 10.1109/TG.2017.2737145

"Pac-Man and it's equally popular successor Ms.Pac-Man are often attributed to being the frontrunners of the golden age of arcade video games. Their impact goes well beyond the commercial world of video games and both games have featured in numerous academic research projects over the last two decades. In fact, scientific interest is on the rise and many avenues of research have been pursued, including studies in robotics, biology, sociology, and psychology. The most active field of research is computational intelligence, not least because of popular academic gaming competitions that feature Ms. Pac-Man. This paper summarizes the peer-reviewed research that focuses on either game (or close variants thereof) with particular emphasis on the field of computational intelligence. The potential usefulness of games like Pac-Man for higher education is also discussed and the paper concludes with a discussion of prospects for future work."

IEEE Transactions on Cognitive and Developmental Systems

Decision Making in Multiagent Systems: A Survey, by Y. Rizk, M. Awad, and E. W. Tunstel, *IEEE Transactions on Cognitive and Developmental Systems*, Vol. 10, No. 3, September 2018, pp. 514-529.

Digital Object Identifier: 10.1109/TCDS.2018.2840971

"Intelligent transport systems, efficient electric grids, and sensor networks for data collection and analysis are some examples of the multiagent systems (MAS) that cooperate to achieve common goals. Decision making is an integral part of intelligent agents and MAS that will allow such systems to accomplish increasingly complex tasks. In this survey, the authors investigate state-of-the-art work within the past five years on cooperative MAS decision making models, including Markov decision processes, game theory, swarm intelligence, and graph theoretic models. They survey algorithms that result in optimal and suboptimal policies such as reinforcement learning, dynamic programming, evolutionary computing, and neural networks. The authors also discuss the application of these models to robotics, wireless sensor networks, cognitive radio networks, intelligent transport systems, and smart electric grids. In addition, the authors define key terms in the area and discuss remaining challenges that include incorporating big data advancements to decision making, developing autonomous, scalable and computationally efficient algorithms, tackling more complex tasks, and developing standardized evaluation metrics. While recent surveys have been published on this topic, the authors present a broader discussion of related models and applications."

Artificial Intelligent System for Automatic Depression Level Analysis Through Visual and Vocal Expressions, by A. Jan, H. Meng, Y. F. B. A. Gaus, and F. Zhang, *IEEE Transactions on Cognitive and Developmental Systems*, Vol. 10, No. 3, September 2018, pp. 668-680.

Digital Object Identifier: DOI: 10.1109/TCDS.2017.2721552

"A human being's cognitive system can be simulated by artificial intelligent systems. Machines and robots equipped with cognitive capability can automatically recognize a humans mental state through their gestures and facial expressions. In this paper, an artificial intelligent system is proposed to monitor depression. It can predict the scales of Beck depression inventory II (BDI-II) from vocal and visual expressions. First, different visual features are extracted from facial expression images. Deep learning method is utilized to extract key visual features from the facial expression frames. Second, spectral low-level descriptors and mel-frequency cepstral coefficients features are extracted from short audio segments to capture the vocal expressions. Third, feature dynamic history histogram (FDHH) is proposed to capture the temporal movement on the feature space. Finally, these FDHH and audio features are fused using regression techniques for the prediction of the BDI-II scales. The proposed method has been tested on the public Audio/Visual Emotion Challenges 2014 dataset as it is tuned to be more focused on the study of depression. The results outperform all the other existing methods on the same dataset."

IEEE Transactions on Emerging Topics in Computational Intelligence

An All-Memristor Deep Spiking Neural Computing System: A Step Toward Realizing the Low-Power Stochastic Brain, by P. Wijesinghe, A. Ankit, A. Sengupta, and K. Roy, *IEEE Transactions on Emerging Topics in Computational Intelligence*, Vol. 2, No. 5, October 2018, pp. 345-358.

Digital Object Identifier: 10.1109/TETCI.2018.2829924

"Deep analog artificial neural networks (ANNs) perform complex classification problems with remarkably high accuracy. However, they rely on humongous amount of power to perform the calculations, veiling the accuracy benefits. The biological brain, on the other hand, is significantly more powerful than such networks and consumes orders of magnitude less power, indicating us about some conceptual mismatch. Given that the biological neurons communicate using energy efficient trains of spikes, and the behavior is nondeterministic, incorporating these effects in deep artificial neural networks may drive us few steps toward a more realistic neuron. In this paper, we propose how the inherent stochasticity of nanoscale resistive devices can be harnessed to emulate the functionality of a spiking neuron that can be incorporated in deep stochastic spiking neural networks (SNN). At the algorithmic level, we propose how the training can be modified to convert an ANN to an SNN while supporting the stochastic activation function offered by these devices. We devise circuit architectures to incorporate stochastic memristive neurons along with memristive crossbars, which perform the functionality of the synaptic weights. We tested the proposed all-memristor deep stochastic SNN for image classification and observed only about 1% degradation in accuracy with the ANN baseline after incorporating the circuit and device related nonidealities. We witnessed that the network is robust to certain variations and consumes ~6.4× less energy than its complementary metal oxide semiconductor (CMOS) counterpart."