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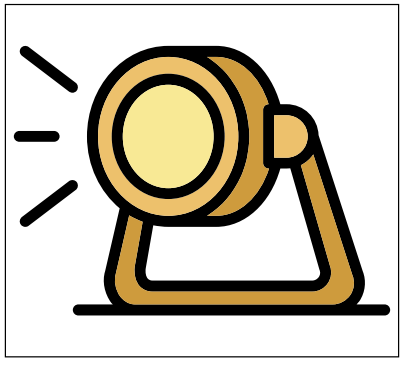
CIS Publication Spotlight

IEEE Transactions on Neural Networks and Learning Systems

Self-Organizing Democratized Learning: Toward Large-Scale Distributed Learning Systems, by M. N. H. Nguyen, S. R. Pandey, T. N. Dang, E.-N. Huh, N. H. Tran, W. Saad, and C. S. Hong, *IEEE Transactions on Neural Networks and Learning Systems*, Vol. 34, No. 12, Dec. 2023, pp. 10698–10710.

Digital Object Identifier: 10.1109/TNNLS.2022.3170872

"Emerging cross-device artificial intelligence (AI) applications require a transition from conventional centralized learning systems toward large-scale distributed AI systems that can collaboratively perform complex learning tasks. In this regard, democratized learning (Dem-AI) lays out a holistic philosophy with underlying principles for building large-scale distributed and democratized



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machine learning systems. The outlined principles are meant to study a generalization in distributed learning systems that go beyond existing mechanisms such as federated learning (FL). Moreover, such learning systems rely on hierarchical self-organization of well-connected distributed learning agents who have limited and highly personalized data and can evolve and regulate themselves based on the underlying duality of specialized and generalized processes. Inspired by Dem-AI philosophy, a novel distributed learning approach is proposed in this article. The approach consists of a self-organizing hierarchical structuring mechanism based on agglomerative clustering, hierarchical generalization, and corresponding learning mechanism. Subsequently, hierarchical generalized learning problems in recursive forms are formulated and shown to be approximately solved using the solutions."

IEEE Transactions on Fuzzy Systems

The Overlapping Community-Driven Feedback Mechanism to Support Consensus in Social Network Group Decision Making, by F. Ji, J. Wu, F. Chiclana, S. Wang, H. Fujita, and E. Herrera-Viedma, *IEEE Transactions on Fuzzy Systems*, Vol. 31, No. 9, Sep. 2023, pp. 3025–3039.

Digital Object Identifier: 10.1109/TFUZZ.2023.3241062

"Social network group decision making (SN-GDM) provides valuable support for obtaining agreed decision results by effectively utilizing the connected social trust relationships among

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individuals. However, the impact of intricately overlapped social trust relationships within overlapping communities on evaluation modifications in the SN-GDM consensus reaching process is seldom considered. To alleviate this issue, this study attempts to construct an overlapping community-driven feedback mechanism for improving consensus in SN-GDM. The Lancichinetti–Fortunato method is used to detect the overlapping community structures under social trust networks. Subsequently, the trusted recommendation advice is conducted within overlapping communities, which guides the inconsistent subgroups to make an interaction with each other to reach higher consensus level. Then, an associated feedback mechanism for SN-GDM with overlapping communities is proposed, which enables the inconsistent subgroups to minimize the consensus cost by selecting personalized feedback parameters. Moreover, it shows that the overlapping communities based feedback mechanism is superior to the feedback mechanisms with nonoverlapping communities. Finally, an illustrative example is included, which is also used to testify the efficacy of proposal by comparing the consensus cost under different representative recommendation advice in overlapping social trust networks."

Quantifying Prediction Uncertainty in Regression Using Random Fuzzy Sets: The ENNreg Model, by T. Denœux, *IEEE Transactions on Fuzzy Systems*, Vol. 31, No. 10, Oct. 2023, pp. 3690–3699.

Digital Object Identifier: 10.1109/TFUZZ.2023.3268200

"In this article, we introduce a neural network model for regression in which prediction uncertainty is quantified by Gaussian random fuzzy numbers (GRFNs), a newly introduced family of random fuzzy subsets of the real line that generalizes both Gaussian random variables and Gaussian possibility distributions. The output GRFN is constructed by combining GRFNs induced by prototypes using a combination operator that generalizes Dempster's rule of evidence theory. The three output units indicate the most plausible value of the response variable, variability around this value, and epistemic uncertainty. The network is trained by minimizing a loss function that generalizes the negative log-likelihood. Comparative experiments show that this method is competitive, both in terms of prediction accuracy and calibration error, with state-of-the-art techniques such as random forests or deep learning with Monte Carlo dropout. In addition, the model outputs a predictive belief function that can be shown to be calibrated, in the sense that it allows us to compute conservative prediction intervals with specified belief degree."

IEEE Transactions on Evolutionary Computation

Learning-Aided Evolution for Optimization, by Z.-H. Zhan, J.-Y. Li, S. Kwong, and J. Zhang, *IEEE Transactions on Evolutionary Computation*, Vol. 27, No. 6, Dec. 2023, pp. 1794–1808.

Digital Object Identifier: 10.1109/TEVC.2022.3232776

"Learning and optimization are the two essential abilities of human beings for problem solving. Similarly, computer scientists have made great efforts to design artificial neural network (ANN) and evolutionary computation (EC) to simulate the learning ability and the optimization ability for solving real-world problems, respectively. These have been two essential branches in artificial intelligence (AI) and computer science. However, in humans, learning and optimization are usually integrated together for problem solving. Therefore, how to efficiently integrate these two abilities together to develop powerful AI remains a significant but challenging issue. Motivated by this, this article proposes a novel learning-aided evolutionary optimization (LEO) framework that plus learning and evolution for solving optimization problems. The LEO is integrated with the evolution knowledge learned by ANN from the evolution process of EC to promote optimization efficiency. The LEO framework is applied to both classical EC algorithms and some state-of-the-art EC algorithms including a champion algorithm, with benchmarking against the IEEE Congress on EC competition data. The experimental results show that the LEO can significantly enhance the existing EC algorithms to better solve both single-objective and multi-/many-objective global optimization problems, suggesting that learning plus evolution is more intelligent for problem solving. Moreover, the experimental results have also validated the time efficiency of the LEO, where the additional time cost for using LEO is greatly deserved. Therefore, the promising LEO can lead to a new and more efficient paradigm for EC algorithms to solve global optimization problems by plus learning and evolution."

IEEE Transactions on Games

HyperColor: A HyperNetwork Approach for Synthesizing Autocolored 3-D Models for Game Scenes Population, by I. Kostiuk, P. Stachura, S. K. Tadeja, T. Trzciński, and P. Spurek, *IEEE Transactions on Games*, Vol. 15, No. 4, Dec. 2023, pp. 613–622.

Digital Object Identifier: 10.1109/TG.2022.3190792

"Designing a 3-D game scene is a tedious task that often requires a substantial amount of work. Typically, this task involves the synthesis and coloring of 3-D models within the scene. To lessen this workload, we can apply machine learning to automate some aspects of the game scene development. Earlier research has already tackled automated generation of the game scene background with machine learning. However, model autocoloring remains an underexplored problem. The automatic coloring of a

3-D model is a challenging task, especially when dealing with the digital representation of a colorful, multipart object. In such a case, we have to "understand" the object's composition and coloring scheme of each part. Moreover, existing single-stage methods have their caveats. We address these limitations by proposing a two-stage training approach to synthesize autocolored 3-D models. In the first stage, we obtain a 3-D point cloud representing a 3-D object, while in the second stage, we assign colors to points within such a cloud. Next, we generate a 3-D mesh in which the surfaces are colored based on the interpolation of colored points representing vertices of a given mesh triangle. This approach allows us to develop a smooth coloring scheme."

IEEE Transactions on Cognitive and Developmental Systems

A Cognitive Robotics Implementation of Global Workspace Theory for Episodic Memory Interaction With Consciousness, by W. Huang, A. Chella, and A. Cangelosi, *IEEE Transactions on Cognitive and Developmental Systems*, Vol. 16, No. 1, Feb. 2024, pp.266–283.

Digital Object Identifier: 10.1109/TCDS.2023.3266103

"Artificial general intelligence revived in recent years after people achieved significant advances in machine learning and deep learning. This leads to the thinking of how real intelligence could be created. Consciousness theories believe that general intelligence is essentially conscious, yet no universal definition is agreed upon. In this work, global workspace (GW) theory is implemented and integrated with crucial cognitive components. With the focus on episodic memory and inspiration from the nature of episodic memory in psychology and neuroscience, the episodic memory component is implemented within the GW framework. In our experiment, the robotic agent operates in a real-world interactive context, forming episodic memory and demonstrating static, temporal, and context memory capabilities during interactions. Consciousness in this work engages in all formation, maintenance, and retrieval processes of episodic memory. The novelty and contributions of this work are: 1) this work is implementing episodic memory within the consciousness framework, suggesting the sustainable potential of such an integrated approach to cognitive agents with artificial general intelligence (AGI); 2) regarding the limited examples in consciousness-based cognitive architectures, this work attempts to contribute to the diversity of perspectives and approaches; 3) extant episodic memory implementations are suffering from various limitations, while this work summarises some key features for modeling episodic memory within a cognitive architecture; and 4) authors discuss the relationship between episodic memory, consciousness, and general intelligence, proposing the compatibility and relationship between machine consciousness and other AGI research. It is believed that a better alignment between them would further boost the fusion of diverse research for achieving desired cognitive machines."

IEEE Transactions on Emerging Topics in Computational Intelligence

Mutually Adaptable Learning, by Q. Tan, Y. Liu, and J. Liu, *IEEE Transactions on Emerging Topics in Computational Intelligence*, Vol. 8, No. 1, Feb. 2024, pp. 240–254.

Digital Object Identifier:10.1109/TETCI.2023.3300183

"In real-world applications that involve complex data dependencies, it would be essential to proceed with machine learning tasks in an adaptable manner. This article presents a novel Mutually Adaptable Learning (MAL) approach that allows for, on the one hand, extracting the most crucial information from data, and on the other hand, maximally utilizing it through model learning, in a mutually adaptable manner. We elaborate our MAL approach by explaining how it determines the necessity for the adaptation of both features and the learning model, integratively adapts between feature selection and model learning, and optimally achieves the learning objective. To systematically validate the effectiveness of MAL, we conduct comprehensive experiments on challenging learning tasks from two representative domains: spatiotemporal prediction and chaotic behavioral prediction, where the complex data dependencies are general encountered. Results demonstrate that MAL outperforms existing learning methods. Moreover, we show that the formulated objective can be attained under an information-theoretic guarantee. With both empirical and theoretical supports, MAL offers an effective solution to the problem of feature and model adaptation to achieve desired learning objective for given complex tasks."

IEEE Transactions on Artificial Intelligence

Hierarchical Reinforcement Learning for Air Combat at DARPA's AlphaDogfight Trials, by A. P. Pope, J. S. Ide, D. Mićović, H. Diaz, J. C. Twedt, K. Alcedo, T. T. Walker, D. Rosenbluth, L. Ritholtz, and D. Javorsek, *IEEE Transactions on Artificial Intelligence*, Vol. 4, No. 6, Dec. 2023, pp. 1371–1385.

Digital Object Identifier: 10.1109/TAI.2022.3222143

"Autonomous control in high-dimensional, continuous state spaces is a

persistent and important challenge in the fields of robotics and artificial intelligence. Because of high risk and complexity, the adoption of AI for autonomous combat systems has been a long-standing difficulty. In order to address these issues, DARPA's Alpha-Dogfight Trials (ADT) program sought to vet the feasibility of and increase trust in AI for autonomously piloting an F-16 in simulated air-to-air combat. Our submission to ADT solves the high-dimensional, continuous control problem using a novel hierarchical deep reinforcement learning approach consisting of a high-level policy selector and a set of separately trained low-level policies specialized for excelling in specific regions of the state space. Both levels of the hierarchy are trained using off-policy, maximum entropy methods with expert knowledge integrated through reward shaping. Our approach outperformed human expert pilots and achieved a second-place rank in the ADT championship event."