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CIS Publication Spotlight

IEEE Transactions on Neural Networks and Learning Systems

An Integrated Learning and Filtering Approach for Fault Diagnosis of a Class of Nonlinear Dynamical Systems, by C. Keliris, M. M. Polycarpou, and T. Parisini, *IEEE Transactions on Neural Networks and Learning Systems*, Vol. 28, No. 4, April 2017, pp. 988–1004.

Digital Object Identifier: 10.1109/TNNLS.2015.2504418

"This paper develops an integrated filtering and adaptive approximation-based approach for fault diagnosis of process and sensor faults in a class of continuous-time nonlinear systems with modeling uncertainties and measurement noise. The proposed approach integrates learning with filtering techniques to derive tight detection thresholds, which is accomplished in two ways: 1) by learning the modeling uncertainty through adaptive approximation methods and 2) by using filtering for dampening measurement noise. Upon the detection of a fault, two estimation models, one for process and the other for sensor faults, are initiated in order to identify the type of fault. Each estimation model utilizes learning to estimate the potential fault that has occurred, and adaptive isolation thresholds for each estimation model are designed. The fault type is deduced based on an exclusion-based logic, and fault detectability and identification conditions are rigorously derived, characterizing quantitatively the class of faults that can be detected and identified by the proposed scheme. Finally, simulation results are used to demonstrate the effectiveness of the proposed approach."

A Collective Neurodynamic Approach to Constrained Global Optimization, by Z. Yan, J. Fan, and J. Wang, *IEEE Transactions on Neural Networks and Learning Systems*, Vol. 28, No. 5, May 2017, pp. 1206–1215.

Digital Object Identifier: 10.1109/TNNLS.2016.2524619

"Global optimization is a long-lasting research topic in the field of optimization, posting many challenging theoretic and computational issues. This paper presents a novel collective neurodynamic method for solving constrained global optimization problems. At first, a one-layer recurrent neural network (RNN) is presented for searching the Karush-Kuhn-Tucker points of the optimization problem under study. Next, a collective neurodynamic optimization approach is developed by emulating the paradigm of brainstorming. Multiple RNNs are exploited cooperatively to search for the global optimal solutions in a framework of particle swarm optimization. Each RNN carries out a precise local search and converges to a candidate solution according to its own neurodynamics. The neuronal state of each neural network is repetitively reset by exchanging historical information of each individual network and the entire group. Wavelet mutation is performed to avoid prematurity, add diversity, and promote global convergence. It is proved in the framework of stochastic optimization that the proposed collective neurodynamic approach is capable of computing the global optimal solutions with probability one provided that a sufficiently large number of neural networks are utilized. The essence of the collective neurodynamic optimization approach lies in its potential to solve constrained global optimization problems in real time. The effectiveness and characteristics of the proposed approach are illustrated by using benchmark optimization problems."

IEEE Transactions on Fuzzy Systems

Multiobjective Evolutionary Optimization of Type-2 Fuzzy Rule-Based Systems for Financial Data Classification, by M. Antonelli, D. Bernardo, H. Hagras, and F. Marcelloni, *IEEE Transactions on Fuzzy Systems*, Vol. 25, No. 2, April 2017, pp. 249–264.

Digital Object Identifier: 10.1109/TFUZZ.2016.2578341

"Classification techniques are becoming essential in the financial world for reducing risks and possible disasters. With the aim of achieving high accuracies, preserving the interpretability, and managing uncertain and unbalanced data, this paper presents a

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novel method to deal with financial data classification by adopting type-2 fuzzy rule-based classifiers (FRBCs) generated from data by a multiobjective evolutionary algorithm. The classifiers employ an approach, denoted as scaled dominance, for defining rule weights in such a way to help minority classes to be correctly classified. The rule bases are generated by exploiting a rule and condition selection approach, which selects a reduced number of rules from a heuristically generated rule base and a reduced number of conditions for each selected rule during the evolutionary process. The weight associated with each rule is scaled by the scaled dominance approach on the fuzzy frequency of the output class, in order to give a higher weight to the minority class. It is shown that the new approach generates FRBCs with, on average, accuracy statistically comparable with and complexity lower than those generated by previous methods. Further, the authors show how these FRBCs are easily interpretable by showing and discussing one of them."

Modeling Stock Price Dynamics With Fuzzy Opinion Networks, by L.-X. Wang, *IEEE Transactions on Fuzzy Systems*, Vol. 25, No. 2, April 2017, pp. 277–301.

Digital Object Identifier: 10.1109/TFUZZ.2016.2574911

"A mathematical model is proposed for word-of-mouth communications among stock investors through social networks and then used to explore how the changes of the investors' social networks influence the stock price dynamics and vice versa. An investor is modeled as a Gaussian fuzzy set (a fuzzy opinion) with the center and standard deviation as inputs and the fuzzy set itself as output. The centers and standard deviations of the fuzzy opinions are the expected prices and their uncertainties, respectively, that are used as inputs to the price dynamic equation. It is proven that with the local reference scheme the investors converge to different groups in finite time, while with the global or external reference schemes all investors converge to a consensus within finite time and the consensus may change with time in the external reference case. It is then shown how to model trend followers, contrarians, and manipulators within this mathematical framework and proven that the biggest enemy of a manipulator is the other manipulators. Monte Carlo simulations are performed to show how the model parameters influence the price dynamics, and a modified version of the model is applied to the daily closing prices of 15 top banking and real estate stocks in Hong Kong, discovering that a sharp increase of the combined uncertainty is a reliable signal to predict the reversal of the current price trend."

IEEE Transactions on Evolutionary Computation

Average Drift Analysis and Population Scalability, by J. He and X. Yao, *IEEE Transactions on Evolutionary Computation*, Vol. 21, No. 3, June 2017, pp. 426–439.

Digital Object Identifier: 10.1109/TEVC.2016.2608420

"This paper aims to study how the population size affects the computation time of evolutionary algorithms (EAs) in a rigorous way. The computation time of EAs can be measured by either the number of generations (hitting time) or the number of fitness evaluations (running time) to find an optimal solution. Population scalability is the ratio of the expected hitting time between a benchmark algorithm and an algorithm using a larger population size. Average drift analysis is introduced to compare the expected hitting time of two algorithms and to estimate lower and upper bounds on the population scalability. Several intuitive beliefs are rigorously analyzed. It is proven that: 1) using a population sometimes increases rather than decreases the expected hitting time; 2) using a population cannot shorten the expected running time of any elitist EA on any unimodal function on the time-fitness landscape, however, this statement is not true in terms of the distance-based fitness landscape; and 3) using a population cannot always reduce the expected running time on deceptive functions, which depends on whether the benchmark algorithm uses elitist selection or random selection."

A Survey of Multiobjective Evolutionary Algorithms Based on Decomposition, by A. Trivedi, D. Srinivasan, K. Sanyal, and A. Ghosh, *IEEE Transactions on Evolutionary Computation*, Vol. 21, No. 3, June 2017, pp. 440–462.

Digital Object Identifier: 10.1109/TEVC.2016.2608507

"Multiobjective evolutionary algorithm based on decomposition (MOEA/D) decomposes a multiobjective optimization problem into a number of scalar optimization subproblems and optimizes them in a collaborative manner using an evolutionary algorithm (EA). Each subproblem is optimized by utilizing the information mainly from its several neighboring subproblems. Since the proposition of MOEA/D in 2007, decomposition-based MOEAs have attracted significant attention from the researchers. Investigations have been undertaken in several directions, including development of novel weight vector generation methods, use of new decomposition approaches, efficient allocation of computational resources, modifications in the reproduction operation, mating selection and replacement mechanism, hybridizing decomposition- and dominance-based approaches, etc. Furthermore, several attempts have been made at extending the decomposition-based framework to constrained multiobjective optimization, many-objective optimization, and incorporate the preference of decision makers. Additionally, there have been many attempts at application of decomposition-based MOEAs to solve complex real-world optimization problems. This paper presents a comprehensive survey of the decomposition-based MOEAs proposed in the last decade."

IEEE Transactions on Computational Intelligence and AI in Games

A Model-Based Approach to Optimizing Ms. Pac-Man Game Strategies in Real Time, by G. Foderaro, A. Swingler, and S, Ferrari, *IEEE Transactions on Computational Intelligence and AI in Games*, Vol. 9, No. 2, June 2017, pp. 153–165.

Digital Object Identifier: 10.1109/TCIAIG.2016.2523508

"Various THE video game Ms. Pac-Man is a challenging example of pursuit-evasion games in which an agent (Ms. Pac-Man) must evade multiple dynamic and active adversaries (ghosts), as well as pursue multiple fixed and moving targets (pills, fruits, and ghosts), all the while navigating an obstacle-populated environment. As such, it provides an excellent benchmark problem for a number of applications including recognizance and surveillance, search-and-rescue and mobile robotics. In Ms. Pac-Man, each ghost implements a different decision policy with random seeds and multiple modalities that are a function of Ms. Pac-Man's decisions. Consequently, the game requires decisions to be made in real time, based on observations of a stochastic and dynamic environment that is challenging to both human and artificial players. This is evidenced by the fact that, despite the recent series of artificial intelligence competitions inviting researchers to develop artificial players to achieve the highest possible score, existing artificial players have yet to achieve the performance level of expert human players. For instance, existing artificial players typically achieve average scores between 9,000 and 18,000 and maximum scores between 20,000 and 35,000. In particular, the highest score achieved at the last Ms. Pac-Man screen capture controller competition was 36,280, while expert human players routinely achieve scores over 65,000 and in some cases as high as 920,000."

IEEE Transactions on Cognitive and Developmental Systems

Perception of Localized Features During Robotic Sensorimotor Development, by A. Giagkos, D. Lewkowicz, P. Shaw, S. Kumar, M. Lee, and Q. Shen, *IEEE Transactions on Cognitive and Developmental Systems*, Vol. 9, No. 2, June 2017, pp. 127–140.

Digital Object Identifier: 10.1109/TCDS.2017.2652129

"The understanding of concepts related to objects is developed over a long period of time in infancy. This paper investigates how physical constraints and changes in visual perception impact on both sensorimotor development for gaze control, as well as the perception of features of interesting regions in the scene. Through a progressive series of developmental stages, simulating ten months of infant development, this paper examines feature perception toward recognition of localized regions in the environment. Results of two experiments, conducted using the iCub humanoid robot, indicate that by following the proposed approach a cognitive agent is capable of scaffolding sensorimotor experiences to allow gradual exploration of the surroundings and local region recognition, in terms of low-level feature similarities. In addition, this paper reports the emergence of vision-related phenomena that match human behaviors found in the developmental psychology literature."

IEEE Transactions on Emerging Topics in Computational Intelligence

A Model-Driven Methodology for the Design of Automatic and Cognitive IoT-Based Systems: Application to Healthcare, by E. Mezghani, E. Exposito, and K. Drira, *IEEE Transactions on Emerging Topics in Computational Intelligence*, Vol. 1, No. 3, June 2017, pp. 224–234.

Digital Object Identifier: 10.1109/TETCI.2017.2699218

"Due to its abilities to capture real-time data concerning the physical world, the Internet of Things (IoT) phenomenon is fast gaining momentum in different applicative domains. Its benefits are not limited to connecting things, but lean on how the collected data are transformed into insights and interact with domain experts for better decisions. Nonetheless, a set of challenges, including the complexity of IoT-based systems, the management of the ensuing big and heterogeneous data, and the system scalability, need to be addressed for the development of flexible smart IoT-based systems that drive business decision-making. Consequently, inspired by the human nervous system and cognitive abilities, we have proposed a set of autonomic cognitive design patterns that alleviate the design complexity of smart IoT-based systems, while taking into consideration big data and scalability management. The ultimate goal of these patterns is to provide generic and reusable solutions for elaborating flexible smart IoT-based systems that are able to perceive the collected data and provide decisions. These patterns are articulated within a model-driven methodology that we have proposed to incrementally refine the system functional and nonfunctional requirements. Following the proposed methodology, we have combined and instantiated a set of patterns for developing a flexible cognitive monitoring system to manage patients' health based on heterogeneous wearable devices. We have highlighted the gained flexibility and demonstrated the ability of our system to integrate and process heterogeneous large-scale data streams. Finally, we have evaluated the system performance in terms of response time and scalability management."