Guest Editorial: Special Section on Developments in Artificial Intelligence for Industrial Informatics

***Abstract*—The emergence of artificial intelligence (AI), empowered by robust computing infrastructure and abundance of data, maintains potential for radical transformation of human society, essentially a third phase in evolution. Numerous research endeavor, policy development, and thought-leadership are presently in progress aimed at discovering data-driven intelligent decision-making solutions for smart cities, smart grids, smart homes, and informed citizens as well as addressing potential risks posed by AI workplace automation. Joining this broad effort, this Special Section contributes six research articles that consolidate recent developments in AI for industrial informatics.**

ARTIFICIAL intelligence (AI) continues to be an enabler and facilitator of Industrial Informatics, in its varying capacities of information analysis, manipulation, and distribution to achieve higher efficiency, effectiveness, reliability, and security from physical operations and physical systems, within industrial environments. Recent advancements in computational infrastructure, algorithmic novelty, and the availability of industrial big data generated by the increasing digitalization of process, systems, and interactions, have proliferated into a paradigm shift use of AI. In the past, focus was on the development of expert systems as industrial AI, which sought to transfer knowledge from engineers and domain experts to computer systems for increased operational efficiencies. In the current environment, the ability to leverage AI is predicted (and in some instances actualized) to be the primary driver of tactical leverage, strategic advantage, competitive strength, leading toward fully autonomous, intelligent systems that effectuate organizational objectives, as well as social, economical, and environmental obligations.

This Special Section received close to 100 submissions of original research across the primary areas of focus in industrial informatics: 1) power and energy; 2) transport; 3) cybersecurity; 4) internet of things and cyber-physical systems; 5) digital health and bioengineering; 6) manufacturing, factories, and buildings; 7) geological engineering; and 8) human–machine interaction. Following a rigorous review process, the guest editors selected six articles based on the significance of research problem and the novelty of AI technique/s. Several research articles are currently undergoing subsequent rounds of review/revisions, and will be published on a later date.

Digital Object Identifier 10.1109/TII.2019.2913769

Visual object detection is an increasingly important consideration for factory automation and Industry 4.0 scenarios. In "Active Object Detection With Multistep Action Prediction Using Deep Q-Network," Han *et al.* formulate active object detection as a sequential action decision process, described using a six-element tuple, consisting of state set, action set, reward function, state transition function, discount factor, and action policy. A deep reinforcement learning framework, the deep Q-network (DQN) with dueling architecture is proposed to solve this formulation, by learning an optimal action policy. It maintains two separate prediction channels, one for the action type and the other for the action range, which supports efficient exploration of the action space. The proposed DQN is evaluated using the active vision dataset, where success rate and average path length are used to measure efficiencies of both one-step action prediction and multistep action prediction.

In "Trajectory Clustering Aided Personalized Driver Intention Prediction for Intelligent Vehicles," Yi *et al.* propose an intelligent personalized driver intention prediction system, specifically for T intersections. The proposed prediction system comprises two layers, offline behavior learning via high-level trajectories and online behavior prediction via low-level vehicle states. Trajectory clustering is used to learn individual behaviors from historical trajectories, and a Classification And Regression Trees (CART) classifier with Bayesian hyperparameter optimization is used for driving behavior prediction. The proposed approach is evaluated using a real-world dataset of driving experiments of diverse drivers, with results showcasing in-depth driving behavior analysis and accurate predictive performance in terms of resubstitution error, cross-validation error, and computation load.

Further expounding the role of machine learning in industrial informatics, "A Two-Stage Approach for the Remaining Useful Life Prediction of Bearings Using Deep Neural Networks," by Xia *et al.* presents a deep neural network based two-stage automated approach for estimating the remaining useful life (RUL) of bearings in industrial machinery. Bearings are fundamental to the smooth operation of most structural and functional machine elements, for instance more than 50% of failures of induction motors are due to degraded bearings. The two-stage deep neural networks (DNN) based prognosis method is initiated by automatically extracting representative features and using these for classification of monitored data into stages of RUL health. This is followed by estimates from multiple prediction

models that are smoothed out for a final RUL measure. Authors report experimental validation using degradation data of bearings from diverse industrial settings, where results demonstrate robust RUL predictions with small volumes of training data.

Operational complexities in the domains of refurbishment, end-of-life dismantling, and remanufacturing are seldomly explored in industrial informatics and AI research. In "TeMA: A Tensorial Memetic Algorithm for Many-Objective Parallel Disassembly Sequence Planning in Product Refurbishment," Pistolesi and Lazzerini make this rare effort by scrutinizing the disassembly process of a refurbishment factory line. They present a novel formulation of parallel disassembly that maximizes the degree of parallelism, ergonomics, and workloads of human operators while reducing operation time and increasing operational efficiency. Authors model the disassembly sequence planning (DSP) problem as an NP-hard many-objective problem, and solve this using the Tensorial Memetic Algorithm (TeMA) that combines genetic computations with local search, in order to peruse Pareto-optimal solutions from the decision-makers' area of preference.

Industrial Internet platforms, where resources, knowledge, and capabilities are represented as manufacturing services, have become more widespread for intraorganizational service collaboration processes. In "Long/Short-Term Utility Aware Optimal Selection of Manufacturing Service Composition Toward Industrial Internet Platforms," Zhang *et al.* formulate long-term and short-term utility of stakeholders in manufacturing service sharing as a multiobjective optimization problem, and solve this using an improved nondominated sorting genetic II (NSGA-II) algorithm that combines Tabu search and improved K-means. The objectives for a consumer's short-term utility are formulated as minimizing delivery time, production cost, and maximizing product quality. The objectives for a provider's long-term utility are defined as prior tasks allocated to them and the possibility of a simultaneous task being assigned. Authors evaluate the proposed approach using a three-dimensional printing task as a case study, where improved convergence, increased stability, and a capacity to accommodate diverse consumers utilities without impacting provider utilities are demonstrated.

Finally, in "PNKLMF-Based Neural Network Control and Learning-Based HC MPPT Technique for Multiobjective Grid Integrated Solar photovoltaic (PV) Based Distributed Generating System," Kumar *et al.* propose a new control technique for a grid-integrated solar photovoltaic system. It is a power normalized kernel least mean fourth algorithm based neural network control (PNKLMF-NN) technique and learning-based hill climbing maximum power point tracking (MPPT) algorithm. The key purpose of this technique is to address the active power requirement of loads from generated solar PV power and excess power fed into the grid. Authors developed a prototype for evaluating its performance, complete with a solar PV simulator and integration to the actual grid. Operations under normal conditions, load unbalanced conditions, solar irradiation variation conditions, grid voltage fluctuations conditions, distorted grid voltage conditions, and day-to-night mode were successfully evaluated.

We are pleased to report that this Special Section on the developments in AI for industrial informatics has been widely accepted and apreciated with the worldwide research community, attracting close to 100 submissions. Given the high quality of work submitted, it was a formidable challenge to select novel, relevant, and practical contributions for the forthcoming publication. It is pertinent to note that the articles selected for publication range across the emerging areas of smart manufacturing, smart energy, and smart transport. This is a robust indication of the new directions for AI research in industrial informatics. We sincerely hope the readership of this journal is able to advance their own research projects and programs, as well as critical thinking of AI innovation based on the diverse insights and novel perspectives presented in the research articles of this Special Section.

The Guest Editors are immensely grateful to the Editor-In-Chief, Prof. Ren C. Luo for the timely opportunity to initiate this Special Section. We express our sincere gratitude to all authorship groups for submitting your novel research, and kindly acknowledge your patience and understanding during the stringent review process. Many thanks to the administrative staff at the IEEE, Lisa and Linda, for your tireless support, throughout the journey, from conception to publication. Thank you.

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