

: EDITORIAL

Industry 4.0: A Special Section in IEEE Access

Industry 4.0 can be said to be the current trend of automation and data exchange in manufacturing technologies. Originally, the term “Industrie 4.0” is from a project in the high-tech strategy of the German government, which hope to promote the computerization of manufacturing. Usually involves terms like cyber-physical systems, Internet of things, and cloud computing. For now, Industry 4.0 becomes an emerging buzzword that is gaining significant interest among all stakeholders of the global industry-related R&D market from academia to international companies. It is a new business model attracting much interest, yet the definitions are not very matured and is an amazing melting pot of disruptive technologies. No doubt, to maximize the impact of Industry 4.0, researchers from different fields and industry have to work together applying the new technologies in practice. On the top of the wave, it is timely to analyze the cross section who can benefit from the novel achievements of Industry 4.0.

With defining the scope of the Special Section, we also make an attempt to grasp the main directions within Industry 4.0. Arbitrary mixtures of related topics are given to call for papers, like utilization of the latest mechatronics in manufacturing processes, extensive data collection and storage, big data analytics, feedback to industrial processes, support of resources, new challenges of security, etc. Of course, in those contents, it may involve automation or the so-call cyber physical systems, system modeling through intelligent techniques, real-time process optimization, among others. After rigorous but fast peer-review processes, 10 papers have been accepted. Among those, two are survey papers. The first paper is an invited article by Trappey *et al.*, “A review of technology standards and patent portfolios for enabling cyber-physical systems in advanced manufacturing.” This paper provides consolidated review of the latest Cyber-Physical Systems (CPS) literature, standards, and patent portfolios analysis. It provides a basis for predicting research and development about future trends and helps policy makers manage technology changes resulting from CPS in Industry 4.0. The other one, “Database- assisted television white space technology: challenges, trends and future research directions,” by Anabi *et al.*, is to present a tutorial review of the challenges related to database-assisted Television white space (TVWS) networks using the SLEPT (social, legal, economic, political, and technological) analysis framework to provide current trends and future research directions in the TVWS context.

Several papers are about techniques in different research areas. “Real-time near-optimal scheduling with rolling horizon for automatic manufacturing cell,” by Hsu and Yang, presents position-based optimization methods to schedule production of automatic cells of a wheel manufacturing factory in a real-time manner. In addition, an original schedule can be partial rescheduled with the preset order sequence by using the linear programming model. “Enhanced industrial machinery condition monitoring methodology based on novelty detection and multi-modal analysis,” by Carino *et al.*, proposes a condition-based monitoring scheme applied to industrial machinery. The effectiveness of this novel scheme has been verified in an automotive industry machine. There is also one paper considering energy efficiency. Authored by Xu and Chang, “A feasible architecture for ARM-based microserver systems considering energy efficiency,” proposes a novel architecture for ARM-based server systems and an ARM-based server cluster board is physically built. The proposed energy-saving server designs with low-power processors are suitable for relative applications in the coming era of Industry 4.0 and the Internet of Things. “Intelligent computer-aided processing planning of multi-axis CNC tapping machine,” by Sun and Chen, develops an intelligent computer-aided process planning based on two performance measures: manufacturability and efficiency. It realizes the Industry 4.0 readiness by developing a realistic and practical CNC computer-aided process planning intelligence kernel. In “Pose determination of a robot manipulator based on monocular vision,” by Kuo *et al.*, based on the kinematics of the manipulator and a calibrated camera, the pose of the manipulator can be determined. The approach can be treated as a backup method for providing a reference solution.

Other papers accepted are about using intelligent techniques in modeling. “Artificial neural network for diffraction based overlay measurement,” by Kuo and Faricha, describes the effect of grating targets with side wall angles on asymmetry in intensity and proposes a method using artificial neural networks for enhancing the accuracy of grating displacement offset prediction in the intelligent nanolithography process control for producing advanced semiconductor fabrication nodes. “Industrial time series modelling by means of the neo-fuzzy neuron,” by Zurita *et al.*, applies a neo-fuzzy neuron method in industrial time series modeling. The obtained results indicate the suitability of the neo-fuzzy neuron method

for industrial process modeling. Finally, “Linewidth reconstruction employing a radial basis function network in optical scatterometry,” by Kuo *et al.*, applies a radial basis function network in coherent Fourier scatterometry to reconstruct the line width of periodic line/space patterns. The nice results revealed the potential to implement the radial basis learning kernel in optical metrology to achieve intelligent lithography.

IEEE Access is an award-winning, multidisciplinary, all-electronic archival journal, continuously presenting the results of original research or development across all of IEEE’s fields of interest. Because of its open access nature, this Special Section is freely accessible to the readers all over the world. Researchers, engineers and all representatives of academia and industry can learn new lessons about the progress of Industry 4.0 in a form, which is somewhere between the sharply focused research papers and the skin-deep magazine style. It is a very hot topic, because billions of public and private funding is available for industrial innovation naturally related to Industry 4.0. We sincerely hope with this Special Section, researchers can find some interesting breakthroughs in their research.

Shun-Feng Su

*National Taiwan University of Science and Technology,
Taiwan*

Imre J. Rudas

Óbuda University, Hungary

Jacek M. Zurada

University of Louisville, USA

Meng Joo Er

Nanyang Technology University, Singapore

Jyh-Horng Chou

*National Kaohsiung University of Applied Sciences,
Taiwan*

Daeil Kwon

*Ulsan National Institute of Science and Technology,
Korea*



SHUN-FENG SU (S’89–M’91–SM’05–F’10) received the B.S. degree from National Taiwan University, Taiwan, in 1983, and the M.S. and Ph.D. degrees from Purdue University, West Lafayette, IN, USA, in 1989 and 1991, respectively, all in electrical engineering.

He is currently a Chair Professor with the Department of Electrical Engineering, National Taiwan University of Science and Technology, Taiwan. He has authored over 200 refereed journal and conference papers in the areas of robotics, intelligent control, fuzzy systems, neural networks, and non-derivative optimization. His current research interests include computational intelligence, machine learning, virtual reality simulation, intelligent transportation systems, smart home, robotics, and intelligent control. He is a CACS Fellow.

Dr. Su is very active in various international/ domestic professional societies. He is currently the President of the International Fuzzy Systems Association. He is also in the Board of Governors of the IEEE Systems, Man, and Cybernetics Society and act as the Young Professionals Subcommittee Chair. He also serves as a Board Member of various academic societies. He also acted as the General Chair, the Program Chair, or various positions for many international and domestic conferences. He currently serves as an Associate Editor of the IEEE TRANSACTIONS ON CYBERNETICS, the IEEE TRANSACTIONS ON FUZZY SYSTEMS, and the IEEE ACCESS, a Subject Editor (Electrical Engineering) of the *Journal of the Chinese Institute of Engineers*, and the Editor-in-Chief of the *International Journal of Fuzzy Systems*.



IMRE J. RUDAS (M'91–SM'93–F'02) received the degree from Bánki Donát Polytechnic, Budapest, in 1971, and the master's degree in mathematics from Eötvös Loránd University, Budapest, the Ph.D. degree in robotics from the Hungarian Academy of Sciences in 1987, the Doctor of Science degree from the Hungarian Academy of Sciences in 2004, and the Doctor Honoris Causa degree from the Technical University of Kožice, Slovakia, the Polytechnica University of Timisoara, Romania, Óbuda University, and the Slovak University of Technology, Bratislava. He received the Honorary Professor title of the Wroclaw University of Technology in 2013.

He served as the President of Budapest Tech from 2003 to 2010. He was the Founder of Óbuda University, the successor of Budapest Tec and was elected as the first President in the period 2010–2014. He served as the President of the Hungarian Rector's Conference and a member of the European University Association in 2008. He is currently active as a Full University Professor.

He is currently the Head of the Steering Committee of the University Research and Innovation Center. He has been the President of the Central European Living Laboratory for Intelligent Robotics since 2014.

Dr. Rudas is a Senior AdCom Member of the Industrial Electronics Society, where he served as a Vice-President from 2000 to 2001. He was elected as the Vice-President for membership and student activities in the IEEE System, Man and Cybernetics Society from 2015 to 2016. He is the Senior Past Chair of the IEEE Hungary Section.

He served the International Fuzzy System Association as the Vice-President and a Treasurer for seven years. He had been the President of the Hungarian Fuzzy Association for ten years. He had been the Vice-President of the Hungarian Academy of Engineers for four years.

He serves as an Associate Editor of some scientific journals, including the IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, a member of the Editorial Board of the *Journal of Advanced Computational Intelligence*, the Editor-in-Chief of the *Acta Polytechnica Hungarica*, and a member of various national and international scientific committees. He is the Founder of the IEEE International Conference Series on Intelligent Engineering Systems, the IEEE International Conference on Computational Cybernetics, the IEEE International Symposium on Computational Intelligence and Informatics, since 2000, the IEEE International Symposium on Machine Intelligence and Informatics, since 2003, the IEEE International Symposium on Intelligent Systems and Informatics, since 2003, the IEEE International Symposium on Applied Computational Intelligence and Informatics, since 2004, and the IEEE International Symposium on Logistics and Industrial Informatics, since 2007. He has served as the General Chair and the Program Chair of numerous scientific international conferences.

His present areas of research activities are computational cybernetics, robotics, cloud robotics, Internet of Anything, soft computing, fuzzy control, and fuzzy sets. He has edited and/or authored three books, authored over 800 papers in international scientific journal, conference proceedings and book chapters, and received over 2000 citations.



JACEK M. ZURADA (LF'14) received the degree from the Gdansk Institute of Technology, Poland, and the Ph.D. degree. He currently serves as a Professor of Electrical and Computer Engineering with the University of Louisville, Kentucky. He has authored or co-authored several books and over 390 papers in computational intelligence, neural networks, machine learning, rule extraction, and bioinformatics, and delivered over 100 invited talks in Mexico, Chile, The Netherlands, China, India, Singapore, Turkey, Hong Kong, Hungary, Germany, Malaysia, Poland, and Italy. His work has been cited over 10 500 times (Google Scholar).

Dr. Zurada served as the IEEE Vice-President, Technical Activities (TAB Chair), in 2014. He also chaired the IEEE TAB Strategic Planning Committee in 2016, the IEEE TAB Periodicals Committee from 2010 to 2011, and the TAB Periodicals Review and Advisory Committee from 2012 to 2013. He was the Editor-in-Chief of the IEEE TRANSACTIONS ON NEURAL NETWORKS from 1997 to 2003, an Associate Editor of the IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS, NEURAL NETWORKS, and a member of the Editorial Board of the

Proceedings of the IEEE. From 2004 to 2005, he served as the President of the IEEE Computational Intelligence Society. He is a Distinguished Lecturer of the IEEE Systems, Man and Cybernetics Society.

He is a member of the Polish Academy of Sciences. He has been a Board Member of the IEEE, the IEEE CIS, and the IJCNN. He received numerous distinctions, including the 2013 Joe Desch Innovation Award, the 2015 INNS Fellow, the 2015 UofL Distinguished Service Award, and five honorary professorships. He is an Associate Editor of the *Neurocomputing*, and several other journals.



MENG JOO ER is currently a Full Professor in electrical and electronic engineering with Nanyang Technological University, Singapore. He served as the Founding Director of the Renaissance Engineering Programme and an elected member of the NTU Advisory Board from 2009 to 2012. He served as a member of the NTU Senate Steering Committee from 2010 to 2012.

He has authored five books *Dynamic Fuzzy Neural Networks: Architectures, Algorithms and Applications* (McGraw Hill, 2003), *Engineering Mathematics with Real-World Applications* (McGraw Hill, 2005), *Theory and Novel Applications of Machine Learning* (In-Tech, 2009), *New Trends in Technology: Control, Management, Computational Intelligence and Network Systems* (SCIYO), and *New Trends in Technology: Devices, Computer, Communication and Industrial Systems* (SCIYO), 18 book chapters, and over 500 refereed journal and conference papers in his research areas of interest.

Dr. Er received the Web of Science Top 1% Best Cited Paper in 2007 and the Elsevier Top 20 Best Cited Paper Award in 2008. In recognition of the significant and impactful contributions to Singapore's development by his research projects, He received the Institution of Engineers, Singapore (IES) Prestigious Engineering Achievement Award in 2011 and 2015. He is also the only dual winner in Singapore IES Prestigious Publication Award in Application in 1996 and the IES Prestigious Publication Award in Theory in 2001. Under his leadership, the NTU Team emerged first runner-up in the Freescale Technology Forum Design Challenge 2008. He received the Teacher of the Year Award for the School of EEE in 1999, the School of EEE Year 2 Teaching Excellence Award in 2008, the Most Zealous Professor of the Year Award in 2009, and the Outstanding Mentor Award in 2014. He also received the Best Session Presentation Award at the World Congress on Computational Intelligence in 2006 and the Best Presentation Award at the International Symposium on Extreme Learning Machine 2012. On top of this, he has over 60 awards received at international and local competitions.

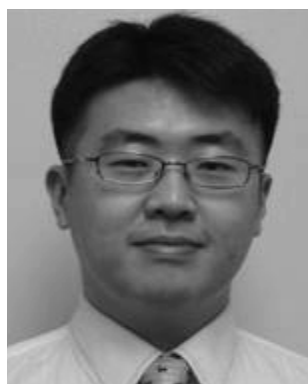
He serves as the Editor-in-Chief of the *Transactions on Machine Learning and Artificial Intelligence* and the *International Journal of Electrical and Electronic Engineering and Telecommunications*. He also serves as an Area Editor of the *International Journal of Intelligent Systems Science* and an Associate Editor of 14 refereed international journals, namely, the IEEE TRANSACTION ON CYBERNETICS, INFORMATION SCIENCES, the *Neurocomputing*, the *Asian Journal of Control*, the *International Journal of Fuzzy Systems*, *ETRI Journal*, the *International Journal of Humanoid Robots*, the *International Journal of Modelling, Simulation and Scientific Computing*, the *International Journal of Applied Computational Intelligence and Soft Computing*, the *International Journal of Business Intelligence and Data Mining*, the *International Journal of Fuzzy and Uncertain Systems*, the *International Journal of Automation and Smart Technology*, and the *International Journal of Intelligent Information Processing*, and an Editorial Board Member of the *Open Automation and Control Systems Journal* and the *EE Times*.

He has been invited to deliver over 60 keynote speeches and invited talks overseas. He has also been active in professional bodies. He has served as the Chairman of the IEEE Computational Intelligence Society (CIS) Singapore Chapter from 2009 to 2011 and the Chairman of the IES Electrical and Electronic Engineering Technical Committee from 2004 to 2006 and from 2008 to 2012. Under his leadership, the IEEE CIS Singapore Chapter received the CIS Outstanding Chapter Award 2012 (The Singapore Chapter is the first chapter in Asia to receive the award). In recognition of his outstanding contributions to professional bodies, he received the IEEE Outstanding Volunteer Award (Singapore Section) and the IES Silver Medal in 2011. Due to his outstanding contributions in education, research, administration, and professional services, he is listed in *Who's Who in Engineering*, Singapore, Edition 2013.



JYH-HORNG CHOU (SM'04–F'15) received the B.S. and M.S. degrees in engineering science from National Cheng-Kung University, Tainan, Taiwan, in 1981 and 1983, respectively, and the Ph.D. degree in mechatronic engineering from National Sun Yat-sen University, Kaohsiung, Taiwan, in 1988. He is currently the Chair Professor with the Electrical Engineering Department, National Kaohsiung University of Applied Sciences, Taiwan. He has co-authored four books, and authored over 285 refereed journal papers. He also holds six patents. His research and teaching interests include intelligent systems and control, computational intelligence and methods, automation technology, robust control, and robust optimization. He was a recipient of the 2011 Distinguished Research Award from the National Science Council of Taiwan, the 2012 IEEE Outstanding Technical Achievement Award from the IEEE Tainan Section, the 2014 Distinguished Research Award from the Ministry of Science and Technology of Taiwan, the Research Award and the Excellent Research Award from the National Science Council of Taiwan 12 times, and numerous academic awards/honors from

various societies. Based on the IEEE Computational Intelligence Society (IEEE CIS) evaluation, his Industrial Application Success Story has got the 2014 winner of highest rank, thus being selected to become the first internationally industrial success story being reported on the IEEE CIS website. He is a fellow of the Institution of Engineering and Technology, the Chinese Automatic Control Society, the Chinese Institute of Automation Engineer, and the Chinese Society of Mechanical Engineers.



DAEIL KWON (M'07) received the bachelor's degree in mechanical engineering from POSTECH, South Korea, and the Ph.D. degree in mechanical engineering from the University of Maryland, College Park, MD, USA. He was a Senior Reliability Engineer with Intel Corporation, Chandler, AZ, USA, where he developed use condition-based reliability models and methodologies for assessing package and system reliability performance. He is currently an Assistant Professor of Human and System Engineering with the Ulsan National Institute of Science and Technology, Ulsan, South Korea. His research interests are focused on prognostics and health management of electronics, reliability modeling, and use condition characterization.

...