INDIN 2024

The 22nd IEEE International Conference on Industrial Informatics INDIN 2024, August 17-20,2024, Beijing, China.

Tutorial Proposal

Title of the Proposal:

Machine Learning and Distributed Optimization for Cyber-Physical Energy Systems

- Presenter(s):

Speaker 1: Professor, Yan Zhang, University of Oslo

Speaker 2: Assistant Professor, Yushuai Li, Aalborg University

- Brief description:

As increasing integration of information and communication technology (ICT) and modern energy systems, the concept of cyber-physical energy systems (CPESs) is presented. By using advanced ICT and energy generation and consumption technologies, CPESs are capable of enhancing system reliability, improving operation security, and reducing failure risk, etc. With the development of diversified energy network architecture, digitalization infrastructure, and e-mobility, there are many unprecedented challenges for smart modelling, operation and control in CPESs.

In this tutorial, we will mainly focus on state-of-the-art machine learning and distributed optimization approaches with application in CPESs. We first will introduce the new concept, features, and challenges of CPESs. Then, we will present several kinds of advanced machine learning methods to tackle the challenges in the aspects of energy management, frequency control, and load monitoring. Next, we will present several kinds of distributed optimization methods to achieve peer-to-peer energy trading and sharing in different physical and communication environments. Finally, we will conclude and point out related open issues.

- Duration: 3 hours

- Outline:

The outline of the Tutorial is summarized as follows:

- Cyber-Physical Energy Systems overview (20mins)
  - New features, requirements and challenges
  - Key enabling technologies
- Machine Learning for Cyber-Physical Energy Systems (75mins)
  - Overview, classifications, and advantages
  - Deep reinforcement learning for energy management
  - Transfer learning for non-intrusive load monitoring
  - Multi-agent deep reinforcement learning for frequency control
- Distributed optimization for Cyber-Physical Energy Systems (75mins)
  - Overview, classifications, and advantages

- Distributed optimization (ADMM, consensus-based) for energy P2P trading and sharing
- Privacy-preserving distributed optimization for energy P2P trading and sharing
- Secure distributed optimization for energy P2P trading and sharing
- Game theory and auction theory for energy trading

- Conclusion, open issues, and Q&A (10mins)

-**Brief CV:**

***Speaker 1**:* Yan Zhang, University of Oslo, Norway (e-mail: yanzhang@ieee.org)

Yan Zhang is currently a Full Professor at the Department of Informatics, University of Oslo, Norway. He received a PhD degree from School of Electrical & Electronics Engineering, Nanyang Technological University, Singapore. Dr. Zhang is an Editor (or Area Editor, Associate Editor) for IEEE top-ranked Transactions/Magazines, e.g., IEEE Transactions on Industrial Informatics, IEEE Internet of Things, IEEE Transactions on Sustainable Computing, IEEE Transactions on Vehicular Technology, and IEEE Network Magazine, etc. He is a symposium/track chair in a number of conferences. He was the Chair of IEEE Communications Society Technical Committee on Green Communications and Computing. Since 2018, Prof. Zhang was a recipient of the global "Highly Cited Researcher" Award. His current research interests include: Energy Internet, Big Data (energy, wireless), cyber-physical energy systems, and next-generation communications networks. His works in these areas have received more than 44000+ citations and his H-index is 108. He is Fellow of IEEE, Fellow of IET, elected member of Academia Europaea, and elected member of Norwegian Academy of Technological Sciences.

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***Speaker 2**:* Yushuai Li, Aalborg University, Denmark (e-mail: yushuaili@ieee.org)

Yushua Li is currently an Assistant Professor with Department of Computer Science, Aalborg University. He has published more than 50 papers in prestigious journals and conferences. Two of them are "Hot Papers and five of them are "Highly Cited Papers". He has an h-index of 17 and 1700+ citations according to Google scholar. As the first author, he received the Best Paper Awards from Journal of Modern Power Systems and Clean Energy (MPCE), and 2023 International Conference on Cyber-energy Systems and Intelligent Energies (ICCSIE). He received the Excellent Young Expert Award from MPCE (2023), the CAA Second Prize of National Natural Science (2022), the CAA First Prize of National Natural Science (2023). He is an associated editor of MPCE. He served as the Student Video / PHD Thesis Competition Chair for IEEE SmartGridComm 2024, Section Chair for SPIES 2022 and IEEE EI2 2022, and Track Chair for ISIE 2024. His major interests include distributed modelling, optimization and control for energy internet, parallel machine learning and digital twin technology.

For more information: https://yushuaili.net/

- **Relevant publications:**

[1] Zhang, Y. Li, and D. W. Gao, et al., "Distributed optimal energy management for

energy internet," IEEE Transactions on Industrial Informatics, vo. 13, no. 6, pp. 3081-3097, 2017.

[2] Y. Li, H. Zhang, and X. Liang, et al., "Event-triggered based distributed cooperative energy management for multienergy systems," IEEE Transactions on Industrial Informatics, vol. 15, no. 14, pp. 2008-2022, 2019.

[3] Y. Li, D. W. Gao, and W. Gao, et al., "Double-mode energy management for multi-energy system via distributed dynamic event-triggered Newton-Raphson algorithm," IEEE Transactions on Smart Grid, vol. 11, no. 6, pp. 5339-5356, 2020.

[4] Y. Li, D. W. Gao, and W. Gao, et al., "A distributed double-Newton descent algorithm for cooperative energy management of multiple energy bodies in energy internet," IEEE Transactions on Industrial Informatics, vol. 17, no. 9, pp. 5993-6003, 2021.

[5] Y. Li et al., W. Gao, and W. Yan, et al., "Data-driven optimal control strategy for virtual synchronous generator via deep reinforcement learning approach," Journal of Modern Power Systems and Clean Energy, vol. 9, no. 4, pp. 919-929, 2021.

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[10] X. Yang, X. Guan, N. Wang, Y. Liu, H. Wu and Y. Zhang, "Cloud-Edge-End Intelligence for Fault-tolerant Renewable Energy Accommodation in Smart Grid," IEEE Transactions on Cloud Computing, DOI: 10.1109/TCC.2021.3133540.

[11] X. Zhou, X. Guan, D. Sun, H. Jiang, J. Peng, Y. Jin and Y. Zhang, "Transient Stability Assessment Based on Gated Graph Neural Network with Imbalanced Data in Internet of Energy," IEEE Internet of Things Journal, vol.9, no.12, pp. 9320 - 9331, June 2022.

[12] H. Chung, S. Maharjan, Y. Zhang, F. Eliassen, and K. Strunz, "Optimal Energy Trading with Demand Responses in Cloud Computing Enabled Virtual Power Plant in Smart Grids," IEEE Transactions on Cloud Computing, vol.10, no.1, pp.17-30, 2022 .

[13] M. Zhang, F. Eliassen, A. Taherkordi, H. Jacobsen, H. Chung and Y. Zhang, "Demand Response Games for Peer-to-Peer Energy Trading with the Hyperledger Blockchain," IEEE Transactions on Systems, Man and Cybernetics: Systems, vol.52, no.1, pp.19-31, Jan. 2022.

[14] S. Mohammadi, F. Eliassen, Y. Zhang, and H. Jacobsen, "Detecting False Data Injection Attacks in Peer to Peer Energy Trading Using Machine Learning," IEEE Transactions on Dependable and Secure Computing, vol.19, no.5, pp. 3417 - 3431, Sept.-Oct. 2022.

[15] H. Chung, S. Maharjan, Y. Zhang, and F. Eliassen, "Distributed Deep Reinforcement Learning for Intelligent Load Scheduling in Residential Smart Grid," IEEE Transactions on Industrial Informatics, vol.17, no.4, pp. 2752-2763, April 2021.

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[17] H. Chung, S. Maharjan, Y. Zhang, F. Eliassen and K. Strunz, "Placement and Routing Optimization for Automated Inspection with UAVs: A Study in Offshore Wind Farm," IEEE Transactions on Industrial Informatics, vol.17, no.5, pp. 3032-3043, May 2021.

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[20] K. Anoh, S. Maharjan, A. Ikpehai, Y. Zhang and B. Adebisi, "Energy Peer-to-Peer Trading in Virtual Microgrids in Smart Grids: A Game-Theoretic Approach," IEEE Transactions on Smart Grid, vol.11, no.2, pp. 1264 - 1275, March 2020.

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[24] J. Kang, R. Yu, X. Huang, S. Maharjan, Y. Zhang, and E. Hossain, "Enabling Localized Peer-to-Peer Electricity Trading Among Plug-in Hybrid Electric Vehicles Using Consortium Blockchains," IEEE Transactions on Industrial Informatics, vol.13, no.6, pp. 3154 -3164, Dec. 2017.

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