Xiang Huo

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Department of Electrical and Computer Engineering
University of Utah, Salt Lake City, UT, USA

Research Interests

Optimization, Learning, and Control:

- Distributed and decentralized optimization algorithms for large-scale distributed energy resource (DER) control problems
- Reinforcement learning (RL) for the optimal and safe operation of distribution networks

Power and Energy Systems:

- Schedule of DERs in power grid applications, such as solar photovoltaic (PV) and energy storage system (ESS)
- Harmonious vehicle-grid integration of electric vehicles (EVs) to provide ancillary services

Privacy Preservation:

- Privacy preservation of multi-agent cooperative computation

Education

University of Utah, Salt Lake City, USA *Aug. 2019 - Present*
Ph.D. Candidate, Electrical and Computer Engineering GPA: 4.0/4.0

Harbin Institute of Technology, Harbin, China *Sept. 2017 - July 2019*
M.S., Control Science and Engineering GPA: 4.0/4.0

Harbin Institute of Technology, Harbin, China *Sept. 2013 - July 2017*
B.S., Automation GPA: 3.73/4.0

Research Experience

University of Utah Salt Lake City, USA
Department of Electrical and Computer Engineering *Aug. 2019 - Present*

Research Assistant in *Energy Control and Optimization Lab* led by Dr. Mingxi Liu

Working on developing new algorithms to address scalability and privacy in large-scale cooperative multi-agent optimizations. Specifically, I am experienced in research topics including

- Design of scalable control strategies for large-scale optimization problems
  - Proposed a scalable decentralized shrunken primal-multi-dual subgradient (SPMDS) algorithm for multi-agent systems
  - Developing new DER control methods to achieve ancillary services in distribution networks
- Develop RL-based data-driven strategies for power energy management
  - Developed a safe RL approach considering physics-informed constraints in grid operation and DER control

  - Gradient-based optimal policy optimization for RL and control
- Implementation of privacy preservation in distributed/decentralized computation
  - Designed privacy-preserving paradigms based on homomorphic cryptosystem
  - Experienced in multi-party secure computation structures like secret sharing schmes
  - Built up real-world platform based on Raspberry Pi boards for theoretical validation
  - Design of a cyber-secure framework for the project *Visual-Enhanced Cooperative Traffic Operations (VECTOR) System* funded by the U.S. Department of Energy

Oak Ridge National Laboratory Oak Ridge, USA
Energy Systems Integration & Controls Section *June 2022 - Aug. 2022*

Research Intern in *Grid Interactive Controls Group* supervised by Dr. Jin Dong

Working on *Sustainable ORNL Initiative Project* that provisions energy efficiency retrofits to old facility buildings. This project aims to improve computing efficiency, enhance operational compatibility, and reduce the carbon footprint of grid-interactive efficient buildings (GEBs).

- Design of a scalable, efficient, and compatible control strategy for GEBs
  - Development of a two-level hybrid decentralized-centralized (HDC) algorithm that aims at providing both grid-level and building-level services
  - Achieved scalability and high computing efficiency *w.r.t.* the number of DERs as well as GEBs in the distribution network
  - Investigated the asynchronous communications with heterogeneous temporal scales to improve the system compatibility
- Benchmark the problem formulation and algorithm design through a real-world set up
  - Built mathematical models of the office building, PV, EV, and ESS to formulate a constrained optimization problem
  - Experimented and interpreted the potentials of integrating the DERs into an office building at ORNL in terms of cost-benefit analysis, carbon emissions, and the resilience
  - Collaborated with interdisciplinary teams from building modeling, grid, and control side to lead the research and support project deliverables

Harbin Institute of Technology Harbin, China
Department of Control Science and Engineering *Set. 2017 - July 2019*

Research Assistant in *Research Institute of Intelligent Control and Systems* led by Dr. Huijun Gao

- Design of high performance trajectory tracking control algorithms based on Scara manipulator
  - Designed of a nonlinear disturbance observer and improved nominal model to achieve the system robustness
  - Proposed a fuzzy adaptive algorithm based on dynamic surface to control the trajectory tracking of the Scara manipulator

Project & Proposal Experience

- ▷ Scalable and Secure Control of Distributed Grid-Edge Resources for Enhanced Grid Reliability, *PI: Mingxi Liu, University of Utah*, 2022 - present

- Participated in reviewing literature regarding scalability and security challenges
- Summarized the pros and cons of our work and proposed feasible future research directions

▷ ORNL Sustainable Campus Initiative Project, *PI: Jianming (Jamie) Lian, Oak Ridge National Laboratory*, June 2022 - Aug. 2022

- Prepared presentation for the stake holders to show the multifarious impacts of the proposal

▷ Visual-Enhanced Cooperative Traffic Operations (VECTOR) System, *PI: Xiaopeng (Shaw) Li, University of South Florida*, 2021 - present

▷ Electrifying and Broadbanding the Comb Ridge/El Capitan Community in Kayenta, *PI: Dalton Singer, The Navajo Nation Tribal Government-Kayenta Chapter*, 2021 - present

- Assisted in the administrative paper work and concept design for pre-application and proposal preparation
- Conducted field trips to the Navajo Nation Tribal Land for technical validation, worked closely with the Native Chapters and commercial vendors for project implementation

Teaching Experingce

▷ Teaching Assistant for *ECE 3600 - Introduction to Electric Power Engineering* *Spring 2023*

▷ Teaching Assistant for *ECE 3510 - Introduction To Feedback Systems* *Spring 2023*

Publications

Journal Papers

[J1] **X. Huo**, M.F. Fard, and M. Liu, "Privacy and security in distribute energy resources optimization: An overview," (In progress).

[J2] **X. Huo** and M. Liu, "Privacy-preserving distributed energy resource control with decentralized cloud computing," (Submitted).

[J3] **X. Huo**, J. Dong, B. Cui, B. Liu, J. Lian, and M. Liu, "Two-level decentralized-centralized control of distributed energy resources in grid-interactive efficient buildings," *IEEE Control System Letters*, vol. 7, pp. 997-1002, 2022.

[J4] **X. Huo** and M. Liu, "Distributed privacy-preserving electric vehicle charging control based on secret sharing," *Electric Power Systems Research*, vol. 211, 2022.

[J5] **X. Huo** and M. Liu, "Privacy-preserving decentralized multi-agent cooperative optimization – paradigm design and privacy analysis," *IEEE Control Systems Letters*, vol. 6, pp. 824-829, 2021.

[J6] **X. Huo** and M. Liu, "Encrypted decentralized multi-agent optimization for privacy preservation in cyber-physical systems", *IEEE Transactions on Industrial Informatics*, vol. 19, pp. 750-761, 2021.

[J7] **X. Huo** and M. Liu, "Two-facet scalable cooperative optimization of multi-agent systems in the networked environment", *IEEE Transactions on Control Systems Technology*, vol. 30, pp. 2317-2332, 2022.

Conference Papers

[C1] **X. Huo**, B. Liu, M. Liu, J. Dong, and J. Lian, "Optimal management of residential energy buildings via enhanced safe reinforcement learning," in *Proceedings of the Hawaii International Conference on System Sciences*, Honolulu, HI, Jan. 3-6, 2024. (Submitted).

[C2] **X. Huo** and M. Liu, "On privacy preservation of electric vehicle charging control via state obfuscation," in *Proceedings of the IEEE Conference on Decision and Control*, Marina Bay Sands, Singapore, Dec. 13-15, 2023.

[C3] M. F. Fard, **X. Huo**, and M. Liu, "Exploration of for-purpose decentralized algorithmic cyber attacks in EV charging control," in *Proceedings of the International Symposium on Industrial Electronics*, Helsinki-Espoo, Finland, June 19-June 21, 2023.

[C4] **X. Huo**, J. Dong, B. Cui, B. Liu, J. Lian, and M. Liu, "Two-level decentralized-centralized control of distributed energy resources in grid-interactive efficient buildings," in *Proceedings of the American Control Conference*, San Diego, CA, USA, May 31-June 2, 2023.

[C5] M.G. Dastgir, **X. Huo**, and M. Liu, "Multi-agent reinforcement learning based electric vehicle charging control for grid-level services," in *Proceedings of the Annual Conference of the IEEE Industrial Electronics Society*, Brussels, Belgium, Oct. 17-20, 2022.

[C6] **X. Huo** and M. Liu, "A secret-sharing based privacy-preserving distributed energy resource control framework," in *Proceedings of the IEEE International Symposium on Industrial Electronics*, Anchorage, AK, USA, June 1-3, 2022.

[C7] **X. Huo** and M. Liu, "Distributed privacy-preserving electric vehicle charging control based on secret sharing," in *Proceedings of the Power Systems Computation Conference*, Porto, Portugal, June 27-July 1, 2022.

[C8] **X. Huo** and M. Liu, "Privacy-preserving decentralized multi-agent cooperative optimization – paradigm design and privacy analysis," in *Proceedings of the IEEE Conference on Decision and Control*, Austin, TX, USA, Dec. 13-17, 2021.

[C9] **X. Huo** and M. Liu, "A novel cryptography-based privacy-preserving decentralized optimization paradigm," in *Proceedings of the IEEE International Conference on Industrial Cyber-Physical Systems*, Victoria, BC, Canada, May 10-12, 2021.

[C10] **X. Huo** and M. Liu, "Privacy-preserving decentralized optimization using homomorphic encryption," in *Proceedings of the IFAC Workshop on Cyber-Physical & Human Systems*, Beijing, China, Dec. 3-5, 2020.

[C11] **X. Huo** and M. Liu, "Decentralized electric vehicle charging control via a novel shrunken primal-multi-dual subgradient (SPMDS) algorithm," in *Proceedings of the IEEE Conference on Decision and Control*, Jeju Island, Korea (South), Dec. 14-18, 2020.

Honors and Awards

1. Student Program Support, PES General Meeting, 2023
2. Proposal Runner-Up of the Wilkes Center Student Innovation Prize ($10K), "*Decarbonize the Diné: A Prefabricated Solar-Driven Communal Solution with Passive Survivability*", the Wilkes Center for Climate Science & Policy, 2023
3. Internship of the Year Award, the University of Utah, 2023
4. ACC Student Travel Grant, American Control Conference, 2023
5. Excellent Research Awards, First place, Chinese Association for Science and Technology in Utah (CAST-UT), 2022
6. Final Presentation Event Winner for the 2021–2022 JUMP into STEM, 2022
7. Proposal Winner of "*Advancing Resilient Communities in Remote Area: A Self-Sustaining and Replicable Solution based in Dennehotso*," the 2021–2022 JUMP into STEM under challenge topic

"*Resilience for All in the Wake of Disaster*" (Organized by the U.S. DOE, ORNL, NREL, and PNNL), 2021

8. Best Student Paper Award, ICPS, 2021
9. Winner of IEEE S&YP 3-Minute Video Contest in ICPS, 2021
10. IES Student and Young Professionals Paper Assistance for The 4th IEEE International Conference on Industrial Cyber-Physical Systems (ICPS), 2021
11. IEEE CSS Student Travel Support for IEEE Conference on Decision and Control (CDC), 2021
12. Outstanding Graduates, (Less than 10%), HIT, 2019
13. Special Scholarship for Graduate Students, (First-class & Top 2%), HIT, 2018
14. The First Prize Scholarships for Graduate Students, HIT, 2017-2019
15. The First Prize Scholarships for Undergraduate Students, Harbin Institute of Technology (HIT), 2015-2016

Professional Activities

Presentations, Posters, & Invited Talks

· "Scalable and privacy-preserving distributed energy resource control over cloud-edge computing," poster session, *The Power & Energy Society General Meeting*, Orlando, Florida, USA, July, 2023.

· "Two-level decentralized-centralized control of distributed energy resources in grid-interactive efficient buildings," oral presentation, *The 2023 American Control Conference*, invited session "*ASME ESTC Invited session on Energy Efficiency in Smart Buildings and Cities*", San Diego, CA, USA, June, 2023.

· "Decarbonize the Diné: A prefabricated solar-driven communal solution with passive survivability", poster session, *Wilkes Climate Summit*, Salt Lake City, UT, USA, May, 2023.

· "Scalable and privacy-preserving distributed energy resource control," *The 26th CAST-UT Annual Conference Innovation and Entrepreneurship*, Salt Lake City, UT, Dec., 2022.

· "A secret-sharing based privacy-preserving distributed energy resource control framework," oral presentation, *The 31st IEEE International Symposium on Industrial Electronics*, Anchorage, AK, June, 2022.

· "Distributed privacy-preserving electric vehicle charging control based on secret sharing," oral presentation, *The XXII Power Systems Computation Conference*, Porto, Portugal, June, 2022.

· "Two-facet scalable cooperative optimization of multi-agent systems in the networked environment," oral presentation, *The 6th IEEE Conference on Control Technology and Applications*, Trieste, Italy, Aug., 2022.

· "Advancing resilient communities in remote area: A self-sustaining and replicable solution based in Dennehotso," oral presentation, *The 4th Jump into Stem Final Competition*, Jan., 2022.

· "Privacy-preserving decentralized multi-agent cooperative optimization – paradigm design and privacy analysis," oral presentation, *The 60th IEEE Conference on Decision and Control*, Austin, TX, USA, Dec., 2021.

· "A novel cryptography-based privacy-preserving decentralized optimization paradigm," oral presentation, *The 5th IEEE International Conference on Industrial Cyber-Physical Systems*, Victoria, BC, Canada, May, 2021.

· "Decentralized electric vehicle charging control via a novel shrunken primal-multi-dual subgradient (SPMDS) algorithm," oral presentation, *The 59th IEEE Conference on Decision and Control*, Jeju Island, Korea (South), Dec., 2020.

Reviewer

Journals

· IEEE Transactions on Energy Markets, Policy and Regulation, 2023 - present

· IET Control Theory & Applications, 2023 - present

· Measurement and Control, 2023 - present

· IEEE Transactions on Industrial Electronics, 2022 - present

· IEEE Transactions on Industrial Informatics, 2022 - present

· Journal of Engineering Research and Sciences, 2022 - present

· Frontiers in Energy Research, Section Smart Grids, 2021 - present

· IEEE Open Journal of the Industrial Electronics Society, 2021 - present

· International Journal of Robust and Nonlinear Control, 2021 - present

· Canadian Journal of Electrical and Computer Engineering 2020 - present

Conferences

· Texas Power and Energy Conference (TPEC), 2023

· IEEE Electrical Power and Energy Conference (EPEC), 2022

· American Control Conference (ACC), 2023

· International Conference on Computer Science and Application Engineering (CSAE), 2022

· International Conference on Networks, Communication and Information Technology (NCIT), 2022

· North American Power Symposium (NAPS), 2022

· IEEE International Conference on Industrial Cyber-Physical Systems (ICPS), 2022, 2023

· IEEE International Conference on Control & Automation (ICCA), 2022

· IEEE Conference on Control Technology and Applications (CCTA), 2022, 2023

· IEEE International Symposium on Industrial Electronics (ISIE), 2022

· IEEE International Conference on Industrial Cyber-Physical Systems (ICPS), 2021

· IEEE International Conference on Control & Automation (ICCA), 2020

· IFAC Conference on Cyber-Physical & Human-Systems (CPHS), 2020

· Annual Conference of the IEEE Industrial Electronics Society (IES), 2020

· IEEE International Conference on Industrial Informatics Online Event (INDIN), 2020

Services

· Regional Lead Ambassador of IEEE Region 6 for the *IEEEXtreme 16.0*, 2022

- Session chair of the "Renewable Energy and Sustainable Development" session for the *IEEE International Symposium on Industrial Electronics (ISIE)*, 2022
- Leader of volunteering affairs for *The 54th North American Power Symposium (NAPS)*, 2022
- Member of *IEEE Smart Grid Marketing Committee*, 2022
- Member of *IEEE Smart Grid Meetings Committee*, 2022

Membership

- *Institute of Electrical and Electronics Engineers* (IEEE): Member of *Control Systems Society* (CSS), *Power & Energy Society* (PES), *Industrial Electronics Society* (IES); and American Society of Mechanical Engineers (ASME)

Volunteer

- Evaluator of *Undergraduate Research Symposium (URS)* at the University of Utah, November, 2022
- Volunteer for *NAPS 2022* on organizing conference affairs, coordinating volunteer activities, and technical sections (Sec. 2A Power Systems Operation, Sec. 3A Power Systems Reliability, Sec. 4A Deep Learning Applications in Power Systems, Sec. 5C Applications of Machine Learning in Power Systems, Sec. 6C Renewable Energy Systems II), October, 2022
- Volunteer in *IEEE Digital Privacy Initiative* and the *Connected Vehicles Subgroup*, June, 2022
- Volunteer for *IEEE-ICPS 2021* on section *ICPS Theory and Technologies III*, December, 2021
- Judge for *The University of Utah Science & Engineering Fair (USEF 2022)*, March, 2022

Skills

Programming skills:
Python, Matlab, C/C++, LaTex, Julia

Languages:
English, Mandarin