Hantao Cui, Ph.D.

Electrical Engineering and Computer Science • University of Tennessee, Knoxville • IEEE Senior Member
Center for Ultra-Wide-Area Resilient Electric Energy Transmission Networks (CURENT)
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RESEARCH INTERESTS

- **Open-source computing software, power system dynamics and high-performance computing.**
- **Cyber-physical power grid and communication co-simulation, and hardware-in-the-loop control.**
- **Deep learning methods and applications in nonlinear dynamic system operation and control.**
- **Microgrid and smart distribution system control with distributed energy resources.**
- **Operation and optimization for electricity markets and smart grid under uncertainty.**

RESEARCH POSITIONS

- **Research Assistant Professor** **April 2019 - Present**
  Research Associate **January 2017- April 2019**
  University of Tennessee, Knoxville *Knoxville, TN*
  Chief Technologist of the CURENT Large-Scale Testbed (LTB) project

EDUCATION

- **The University of Tennessee, Knoxville** **Knoxville, TN, USA**
  PhD, Department of Engineering and Computer Science, GPA 3.9/4.0 *August 2013 - December 2018*
  Dissertation: *Large-Scale Simulations of Modern Electric Power Systems* Advisor: Dr. Fangxing Li

- **Southeast University** **Nanjing, Jiangsu, China**
  M.S. in Electrical Engineering, School of Electrical Engineering, GPA 3.7/4.0 *September 2011 - June 2013*
  B.S. in Electrical Engineering, Chien-Shiung Wu Honor College, GPA 3.7/4.0 *September 2007 - June 2011*

Funded Projects

- **Co-PI, $152K**, "Model Free Adaptive Control (MFAC) for Autonomous and Resilient Operation of Military Microgrids", *Department of Defense*, 05/2020-01/2023.
- **Co-PI: $18K**, "Rapidly Attainable Increases in Transmission Capacity Using Power-Electronics", *Department of Energy*, 09/2020-08/2021.
- **Co-PI: $20K**, "Intelligent Control of Refrigerating Load for Peak Reduction", *State of Tennessee Appropriations*, 09/2020-08/2021.

RESEARCH PROJECTS

- **Chief Technologist of Large-Scale Testbed (LTB)** **08/2014 - Present, UT Knoxville**
  Design and implement an integrated cyber-physical hardware-in-the-loop testing platform for large-scale power systems with energy management, communication emulation, control, and visualization [J3, J4, P2, P1].
  CURENT LTB won the 2020 R&D 100 Awards.

  - Develop North American test systems models with high renewable generation.
  - Develop VSC-based multi-terminal HVDC for power flow and transient stability studies.
  - Emulate North American communication networks considering topology, delay and bandwidth.
  - Develop IEEE C37.118.2011 PMU Simulator; implement measurement-based controls in PDCs.
  - Integrate heterogeneous cyber-physical research modules using data streaming with OPAL-RT hardware.
  - Developed CPS simulation tools: ANDES; OpalAPIControl; DiME; LTBNet; LTBVis

- **Author of ANDES, Python Software for Symbolic Power System Modeling and Numerical Analysis**
  A unique hybrid symbolic-numeric framework for that enables descriptive DAE modeling and automatic numerical code generation for simulation [J2].

  - Features high-performance computing, rapid model prototyping, data streaming, strict verification with commercial simulation tools, and integration with various solvers [J1]
  - a rich library of transfer functions and discontinuous components (including limiters, deadbands, and saturation) available for prototyping models, which can be effortlessly instantiated as multiple devices for system analysis
  - the only open-source tool with the industry-grade full dynamic models for solar PV, wind, and energy storage: REGC_A, REEC_A, REEC_C, REPC_A, WTGT_A, WTPT_A, WTAR_A, WTTQ_A, and distributed PV model PVD1
  - The distributed PV and storage models are being used by an NREL project to study the use of distributed PV for automatic generation control (AGC).
  - Open-source and available on GitHub: `https://www.github.com/cuihantao/andes` (51 Stars, 30 Forks)

- **Lead Developer of OpalApiControl, APIs for OPAL-RT RT-LAB Real-Time Simulation**

  - OpalApiControl provides convenient APIs for RT-LAB-based real-time simulation and data streaming.
  - An inter-operable simulation tool with ANDES in the LTB environment.
  - Originated from the work with a *summer research undergraduate student*.
  - Open-source and available on GitHub: `https://www.github.com/curent/opalapicontrol`

- **Lead Developer of LTBNet, A Process-Based Network Emulation for PMU-Based Streaming and Control**

  - LTBNet is a tool for emulating arbitrary network topology for PMU data streaming.
  - Provides interfaces to *Mininet* and *OpenFlow* controllers for cybersecurity studies.
  - Interfaces to PMU and PDC simulators with ANDES and OpalApiControl.
  - Open-source and available on GitHub: `https://www.github.com/curent/ltbnet`

SELECT PUBLICATIONS [Citations: 922, h-index: 15, i_{10}-index: 17]. Google Scholar Link.

- **Journal Publications**

  [J1] **Hantao Cui**, Fangxing Li, and Xin Fang. Effective parallelism for equation and jacobian evaluation in power flow calculation. *To be submitted to IEEE PES Letter*.

  [J2] **Hantao Cui**, Fangxing Li, and Kevin Tomsovic. Hybrid symbolic-numeric framework for power system modeling and analysis. *IEEE Transactions on Power Systems*, in press, 2020.

  [J3] **Hantao Cui**, Fangxing Li, and Kevin Tomsovic. Cyber-physical system testbed for power system monitoring and wide-area control verification. *IET Energy Systems Integration*, 2(1):32–39, 2019.

  [J4] Fangxing Li, Kevin Tomsovic, and **Hantao Cui**. A large-scale testbed as a virtual power grid: For closed-loop controls in research and testing. *IEEE Power and Energy Magazine*, 18(2):60–68, 2020.

  [J5] **Hantao Cui**, Fangxing Li, Xin Fang, Hao Chen, and Honggang Wang. Bilevel arbitrage potential evaluation for grid-scale energy storage considering wind power and LMP smoothing effect. *IEEE Transactions on Sustainable Energy*, 9(2):707–718, 2018.

  [J6] **Hantao Cui**, Fangxing Li, Qinran Hu, Linquan Bai, and Xin Fang. Day-ahead coordinated operation of utility-scale electricity and natural gas networks considering demand response based virtual power plants. *Applied Energy*, 176(15):183–195, 2016.

  [J7] Qiwei Zhang, Fangxing Li, **Hantao Cui**, and et. al. Market-level defense against fdia and a new lmp-disguising attack strategy in real-time market operations. *IEEE Transactions on Power Systems*, in press, 2020.

  [J8] Linquan Bai, Fangxing Li, **Hantao Cui**, and et. al. Interval optimization based operating strategy for gas-electricity integrated energy systems considering demand response and wind uncertainty. *Applied energy*, 167:270–279, 2016.

  [J9] Qingxin Shi, Fangxing Li, and **Hantao Cui**. Analytical method to aggregate multi-machine sfr model with applications in power system dynamic studies. *IEEE Transactions on Power Systems*, 33(6):6355–6367, 2018.

[J10] Xue Li, **Hantao Cui**, Tao Jiang, and et. al. Multichannel continuous wavelet transform approach to estimate electromechanical oscillation modes, mode shapes and coherent groups from synchrophasors in bulk power grids. *International Journal of Electrical Power & Energy Systems*, 96:222–237, 2018.

[J11] Haiteng Han, **Hantao Cui**, Shan Gao, and et. al. A remedial strategic scheduling model for load serving entities considering the interaction between grid-level energy storage and virtual power plants. *Energies*, 11(9):2420, 2018.

[J12] Xue Li, Fangxing Li, Haoyu Yuan, **Hantao Cui**, and Qinran Hu. Gpu-based fast decoupled power flow with preconditioned iterative solver and inexact newton method. *IEEE Transactions on Power Systems*, 32(4):2695–2703, 2017.

[J13] Qingxin Shi, **Hantao Cui**, Fangxing Li, and et. al. A hybrid dynamic demand control strategy for power system frequency regulation. *CSEE Journal of Power and Energy Systems*, 3(2):176–185, 2017.

- **Conference Papers**

  [C1] **Hantao Cui** and Fangxing Li. Andes: A python-based cyber-physical power system simulation tool. In *2018 North American Power Symposium (NAPS)*, pages 1–6. IEEE, 2018.

  [C2] **Hantao Cui**, Fangxing Li, and Haoyu Yuan. Control and limit enforcements for vsc multi-terminal hvdc in newton power flow. In *Power & Energy Society General Meeting, 2017 IEEE*, pages 1–5. IEEE, 2017.

  [C3] **Hantao Cui**, Fangxing Li, Xin Fang, and Runsha Long. Distribution network reconfiguration with aggregated electric vehicle charging strategy. In *Power & Energy Society General Meeting, 2015 IEEE*, pages 1–5. IEEE, 2015.

  [C4] Fangxing Li, Kevin Tomsovic, and **Hantao Cui**. An integrated testbed for power system monitoring, modeling, control and actuation. 2018.

  [C5] Alec Yen, **Hantao Cui**, and Kevin Tomsovic. Cxsparse-based differential algebraic equation framework for power system simulation. In *2018 North American Power Symposium (NAPS)*, pages 1–6. IEEE, 2018.

- **Patents**

  [P1] Fangxing Li, **Hantao Cui**, MohammadReza AhmadzadehRaji, Kevin Louis Tomsovic, Yilu Liu, and Jian Huang. Real-time simulator and controller of power system using distributed data streaming server, October 20 2020. US Patent. 10,809,753.

  [P2] Fangxing Li, **Hantao Cui**, and Kevin Louis Tomsovic. A controller for real-time distributed cyber-physical power system simulation using rapid distributed data streaming and communication network emulation, 2019. Application pending.

PROFESSIONAL SERVICES

- Secretary-elect, *Computating and Analytics Subcommittee* (CAMS), IEEE PES   Starts in 01/2021
- Webmaster, *Computating and Analytics Subcommittee* (CAMS), IEEE PES   08/2018 - 12/2020 (exp.)
- Secretary, *Ultra-Wide-Area HVDC Overlay Studies* Task Force, IEEE PES   08/2018 - Present
- Associate Editor, *Journal of Modern Power Systems and Clean Energy* (MPCE)   01/2019 - Present
- Reviewer, *IEEE Trans. on Power Systems; IEEE Trans. on Smart Grid; and IEEE Trans. on Sust. Energy*
- Reviewer, *Applied Energy*
- Book Reviewer, *Elsevier*

AWARDS AND HONORS

- Elevated to **IEEE Senior Member**   11/2020
- **R&D 100 Award of 2020** won by the CURENT Large-Scale Testbed   09/2020
- **Outstanding Reviewer** for 2019 of *IEEE Transactions on Power Systems*   03/2020
- **Highly Cited Paper Award** 2019 of *Applied Energy*   07/2019

- Outstanding Graduate Research Assistant, EECS Gonzalez Family Awards Banquet   04/2018
- **Top Peer Reviewer** Award (1%) in Engineering on Publons.com   09/2018
- Author of Essential Science Indicators (ESI) **Highed Cited Papers**   03/2018 and 07/2017
- UT Knoxville **Chancellor's Citation** on Extraordinary Professional Promise   04/2017
- **Best Conference Paper**, 2016 IEEE PES General Meeting   07/2016

INVITED PRESENTATIONS AND SEMINARS

- *HVDC Overlays in Testbeds*, Panel Session Presentation at 2019 PES GM, Atlanta   08/2019
- *Cyber-Physical Large-Scale Testbed*, NIST Workshop on Smart Grid Testbeds and Collaborations   04/2019
- *LTB for Closed-Loop Cyber-Physical Simulation*, FUTA-USAID Workshop, Nigeria   08/2018
- Transactions Paper Presentation at the 2017 IEEE PES General Meeting, Chicago   07/2017

TEACHING EXPERIENCES

- **Instructor and Co-Instructor**   **Department of EECS, UTK**
  - Co-Instructor: ECE 421, Electric Energy Systems   Fall 2019
  - Instructor: ECE 496/691, Power and Energy Systems Seminar   Fall 2020, Spring and Fall 2019
- **Graduate Teaching Assistant**   **Department of of EECS, UT Knoxville**
  - ECE 453/599: Computer Networking   Spring 2014
  - ECE 622: Power System Economics   Fall 2013

MENTORING EXPERIENCES

- Mentored a few junior Ph.D. students or junior visiting students: Qingxin Shi, Haiteng Han and Qiwei Zhang.
  - I mentored Qingxin Shi on the topic of frequency regulation using demand response and aggregated frequency models. I worked with him on the modeling and simulation in large-scale systems, the WECC system. We coauthored two journal papers [J9, J13] on the topic.
  - I mentored Haiteng Han, a visiting student. I worked with him on the day-ahead coordinated operation with renewable energy and energy storage and offered ideas on the algorithm for strategic scheduling. We coauthored one journal paper [J11].
- Mentored over 10 summer REU Students for CURENT since 2014.
  - With Runsha Long, a summer REU student in 2014. **Topic: Electric Vehicle Optimization**
    * I mentored Runsha on residential electric vehicle usage pattern analysis using data from *Bureau of Transportation Statistics*. We proposed a conic programming model for distribution system reconfiguration with optimal EV scheduling. Results were published in the 2015 IEEE PES General Meeting.
  - With Alec Yen, an REU student in Spring 2018. **Topic: Sparse Matrix Operation Acceleration**
    * I mentored Alec on improving the efficiency of sparse matrix incremental build algorithms, which is fundamental for power system simulation tools. Experiments are carried out in SuiteSparse CXSparse. Our improved in-place add and set algorithms can accelerate up to 3x depending on the shape of the matrix operands. Results were published in the 2018 NAPS.

VOLUNTEER EXPERIENCES

- Chair, Transactions Paper Forum on Microgrid, IEEE PES General Meeting   August 2019
- Chair, Student Career Development Forum, Power Industry Division, ISA   June 2018
- Mentor, CURENT REU programs   2014 - Present, Knoxville, TN
- CURENT Education Outreach - engineering night   12/2016, Knoxville, TN
- Staff Volunteer, Boy Scouts fall special event at Camp Pellissippi   10/2015, Andersonville, TN

REFERENCES

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