# SANMUKH RAO KUPPANNAGARI

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## PROFESSIONAL PREPARATION

**University of Southern California** *Present*
Post-Doctoral Training in Computer Engineering
Ming Hsieh Department of Electrical and Computer Engineering

**University of Southern California** *Summer 2018*
PhD in Computer Engineering
Ming Hsieh Department of Electrical and Computer Engineering
*Thesis Title:* Discrete Optimization for Supply Demand Matching in Smart Grids
GPA: 3.79/4.00

**Indian Institute of Technology, Guwahati** *May 2011*
Bachelor of Technology, Computer Science and Engineering
Overall CPI: 8.20/10.00

## RESEARCH INTERESTS

*Techniques:* Combinatorial Optimization, Approximation Algorithms, Reinforcement Learning, Distributed Energy Resources (DER) Scheduling in Smart (power) Grids, Cyber Physical Security in Smart Grids

## APPOINTMENTS

· Post Doctoral Scholar - Research Associate, University of Southern California, Los Angeles, Fall '18 - present.

· Intern, US Army Research Laboratory, Playa Vista, CA, Summer '17.

· Intern, MathWorks Inc., Natick, MA, Summer '14.

· Member Technical Staff, Adobe Systems Inc., India, Summer '11 - Summer '13.

## SELECTED PUBLICATIONS

• Chi Zhang, **Sanmukh R. Kuppannagari**, Rajgopal Kannan and Viktor K. Prasanna, *Building HVAC Scheduling Using Reinforcement Learning via Neural Network Based Model Approximation*, The 6th ACM International Conference on Systems for Energy-Efficient Buildings, Cities, and Transportation (BuildSys 2019), November 2019.

• **Sanmukh R. Kuppannagari**, Rajgopal Kannan and Viktor K. Prasanna, *Approximate Scheduling of DERs with Discrete Complex Injections*, Tenth ACM International Conference on Future Energy Systems (ACM e-Energy), June 2019.

• **Sanmukh R. Kuppannagari**, Rajgopal Kannan and Viktor K. Prasanna, *Optimal Discrete Net Load Balancing in Smart Grids with High PV Penetration*, ACM Transactions on Sensor Networks (TOSN) 14.3-4 (2018): 24, 2018.

• **Sanmukh R. Kuppannagari**, Rajgopal Kannan and Viktor K. Prasanna, *Optimal Net Load Balancing in Smart Grids with High PV Penetration*, The 4th ACM International Conference on Systems for Energy-Efficient Built Environments (BuildSys 2017), November 2017.

## PROPOSALS

**Under Review**

- U.S. ARPA-E PERFORM, "DERISK: Data DrivEn Reinforcement Learning Framework for RISK Aware Grid Management," PI: Viktor K. Prasanna, Co-PI: Mo Beshir, Senior Investigator: **Sanmukh R. Kuppannagari**.
- U.S. National Science Foundation, "CNS Core: Small: AccelRITE: Accelerating ReTnforcemenT Learning based AI at the Edge Using FPGAs", PI: Viktor K. Prasanna, Co-PI: **Sanmukh R. Kuppannagari**.
- Sony Research Award Program, "Accelerating AI at the Edge", PI: Viktor K. Prasanna, Senior Investigator: **Sanmukh R. Kuppannagari**.

**Funded**

- U.S. National Science Foundation - 1911229, "OAC Core: Small: Scalable Graph Analytics on Emerging Cloud Infrastructure," PI: Viktor K. Prasanna, Co-PI: **Sanmukh R. Kuppannagari**.
- U.S. Army Research Office - W911NF1910362, "Graph Theoretic Approaches for Cyber Physical Security in Networks," PI: Viktor K. Prasanna, Co-PI: **Sanmukh R. Kuppannagari**.

## RESEARCH EXPERIENCE

**Ming Hsieh Department of Electrical Engineering** September, 2018 - present
*PostDoctoral Scholar - Research Associate* *Los Angeles, CA*

- Data Driven Analytics and Optimization for Increased Solar Penetration [ISGT20, SUST20, TSG20, EENERGYW19, EENERGY19, IoTDI19, SGCOMM18, LOCS19, SUST18a].
- Safety and Robustness in Reinforcement Learning for Smart Building Control [BuildSys19].
- Risk Aware Reinforcement Learning for Resiliency in Tactical Microgrids.
- Accelerating Graph Analytics on Cloud Platforms with Heterogeneous CPU-FPGA nodes [HPEC19, ParFPGA19, ISC20].
- Accelerating Reinforcement Learning on Heterogeneous CPU-FPGA nodes [FPGA20].

**Ming Hsieh Department of Electrical Engineering** August, 2013 - August, 2018
*Research Assistant* *Los Angeles, CA*

- PhD Dissertation: Discrete Optimization for Supply Demand Matching in Smart Grids [Thes18]
- Optimal Net Load Balancing in Smart Grids with High DER penetration [TOSN18, ISGT18, BuildSys17]
- Optimal Customer Selection for Dynamic Demand Response in SmartGrids [ICCS16, CSCI15]
- Lead developer of the DR software which is used to implement Demand Response event in USC SmartGrid for the joint demonstration project between LADWP and USC [IJCAI16]
- Cyber Physical Security in Smart Grids [SUST18b, SUST16].

**Army Research Lab** June 2017 - August 2017
*Summer Intern* *Playa Vista, CA*

- Risk-Aware Sequential Decision Making under Model Uncertainties: Applications in Smart Grids [ISGT18].

## TEACHING EXPERIENCE

- EE 457 - Computer Systems Organization. Fall 2014, Spring 2015, Fall 2015, Fall 2016. Instructor: Prof Gandhi Puvvada (gandhi@usc.edu)
- EE 451 - Parallel and Distributed Computing. Spring 2016, Spring 2017. Instructor: Prof Viktor K. Prasanna (prasanna@usc.edu)

## SYNERGISTIC ACTIVITIES

### Organization

- Program Committee Chair; First Workshop on DataScience for Future Energy Systems, HiPC 2019.
- Program Committee Member; The 9th International Workshop on Computing and Networking for IoT and Beyond, ICDCN Workshop 2020.
- Program Committee Member; 1st International Workshop on Societal Computing for the Internet of Things & You (SoCIeTY), ICDCN Workshop 2020.
- Publicity Chair; Web chair; 26th IEEE/ACM International Conference on High Performance Computing, (HiPC) 2019.
- Web chair; 25th IEEE/ACM International Conference on High Performance Computing,(HiPC) 2019.

### Reviewer Experience

- Reviewer; IEEE BigData, 2019.
- Reviewer; Sustainable Energy, Grids and Network, 2019.
- Reviewer; Methods of Information in Medicine, 2019.
- Reviewer; Transactions on Sustainable Computing (TSUC), 2019.
- Judge; EE Research Festival, University of Southern California, 2019.
- Reviewer; IEEE Access, 2018.
- Reviewer; Transactions on Sustainable Computing (TSUC), 2018.

## MENTORING EXPERIENCE

### PhD

- Chi Zhang - Reinforcement Learning for Safety in Smart Grids
- Chung Ming Chueng - Data Analytics, Smart Grids
- Rachit Rajat - Acceleration of Reinforcement Learning on Edge FPGA Devices
- Yuan Meng - Acceleration of Reinforcement Learning on Edge FPGA Devices
- Sasindu Wijeratne - Accelerating Graph Analytics on Cloud Platforms with FPGAs
- Tian Ye - Accelerating Graph Analytics on Cloud Platforms with FPGAs
- Athanasios Rompokos - Mobile Energy Storage Scheduling for Smart Grid Management

### Masters/Bachelors

- Yang Yang - Accelerating Hash Table on FPGA
- Nivedita Suresh - Discrete Optimization for Net-Load Balancing in Smart Grids
- Xiangchong Liu - Live Energy Map for Visualization of Energy in Smart Grids
- Stefan Binna - Cyber Physical Security in Smart Grids
- Yilin Yang - Risk Aware Reinforcement Learning Framework for Resiliency in Tactical Microgrids
- Ruilin Liu - Risk Aware Reinforcement Learning Framework for Resiliency in Tactical Microgrids
- Akshit Goel - Parallel Graph Sampling on FPGAs

## AWARDS

- Ming Hsieh Institute (MHI) Ph.D. Scholar Finalist, Fall 2017.
- Ming Hsieh Department of Electrical Engineering Charles L. Weber Outstanding Teaching Assistant Honorable Mention, Spring 2017.
- Ming Hsieh Department of Electrical Engineering, Best Research Poster - Honorable Mention, 7th Annual EE Research Festival, Fall 2016.

## REFERENCES

1. **Dr. Viktor K. Prasanna**
   Charles Lee Powell Chair in Engineering
   Director, Center for Energy Informatics (CEI)
   Professor of Electrical Engineering, Computer Engineering Division, and Professor of Computer Science
   University of Southern California
   **Email:** prasanna@usc.edu

2. **Dr. Rajgopal Kannan**
   Researcher
   U. S. Army Research Lab
   **Email:** rajgopal.kannan.civ@mail.mil

3. **Dr. Mohammed Beshir**
   Professor of Electrical and Computer Engineering Practice
   University of Southern California
   **Email:** beshir@usc.edu

4. **Dr. Dominik Engel**
   Head of Center
   Center for Secure Energy Informatics
   Head of Department Network Technologies and Security
   Information Technology and Systems Management
   Fachhochschule Salzburg GmbH
   Salzburg University of Applied Sciences
   **Email:** dominik.engel@fh-salzburg.ac.at

## FULL LIST OF PUBLICATIONS

### Smart Grid - Drafts


[SUST20] Chung Ming Cheung, Sanmukh Rao Kuppannagari, Rajgopal Kannan, and Viktor K Prasanna. "Disaggregation of Behind-The-Meter Solar Generation and Energy Storge Resources". In: *2020 IEEE Conference on Technologies for Sustainability (SusTech)*. Under Review. IEEE. 2020.

[TSG20] Chung Ming Cheung, Sanmukh Rao Kuppannagari, Ajitesh Srivastava, Rajgopal Kannan, and Viktor K Prasanna. "Behind-the-Meter Solar Generation Disaggregation Using Consumer Mixture Models". In: *Preparation for a suitable journal* (2020).


### Smart Grid - Published


[ISGT20] Chung Ming Cheung, Sanmukh Rao Kuppannagari, Rajgopal Kannan, and Viktor K Prasanna. "Load Demand User Profiling in Smart Grids with Distributed Solar Generation," in: *2020 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT)*. IEEE. 2020.

[EENERGYW19] Chung Ming Cheung, Sanmukh Rao Kuppannagari, Rajgopal Kannan, and Viktor K Prasanna. "Towards Improved Real-Time Observability of Behind-Meter PhotoVoltaic Systems: A Data-Driven Approach". In: *Proceedings of the Tenth ACM International Conference on Future Energy Systems*. ACM. 2019, pp. 447–455.

[EENERGY19] Sanmukh Kuppannagari, Rajgopal Kannan, and Viktor K Prasanna. "Approximate Scheduling of DERs with Discrete Complex Injections". In: *Proceedings of the Tenth ACM International Conference on Future Energy Systems*. ACM. 2019, pp. 204–214.

[LOCS19] Ajitesh Srivastava, Sanmukh R Kuppannagari, Rajgopal Kannan, and Viktor K Prasanna. "Minimizing Cost of Smart Grid Operations by Scheduling Mobile Energy Storage Systems". In: *IEEE Letters of the Computer Society* 2.3 (2019), pp. 20–23.

[BuildSys19] Chi Zhang, Sanmukh R Kuppannagari, Rajgopal Kannan, and Viktor K Prasanna. "Building HVAC Scheduling Using Reinforcement Learning via Neural Network Based Model Approximation". In: *Proceedings of the 6th ACM International Conference on Systems for Energy-Efficient Built Environments*. ACM. 2019.

[IoTDI19] Chi Zhang, Sanmukh R Kuppannagari, Chuanxiu Xiong, Rajgopal Kannan, and Viktor K Prasanna. "A cooperative multi-agent deep reinforcement learning framework for real-time residential load scheduling". In: *Proceedings of the International Conference on Internet of Things Design and Implementation*. ACM. 2019, pp. 59–69.

[SUST18b] Stefan Binna, Sanmukh R Kuppannagari, Dominik Engel, and Viktor K Prasanna. "Subset Level Detection of False Data Injection Attacks in Smart Grids". In: *2018 IEEE Conference on Technologies for Sustainability (SusTech)*. IEEE. 2018, pp. 1–7.

[ISGT18] Sanmukh R Kuppannagari, Rajgopal Kannan, and Viktor K Prasanna. "NO-LESS: Near optimal curtailment strategy selection for net load balancing in micro grids". In: *2018 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT)*. IEEE. 2018, pp. 1–5.

[TOSN18] Sanmukh R Kuppannagari, Rajgopal Kannan, and Viktor K Prasanna. "Optimal Discrete Net-Load Balancing in Smart Grids with High PV Penetration". In: *ACM Transactions on Sensor Networks (TOSN)* 14.3-4 (2018), p. 24.

[Thes18] Sanmukh Rao Kuppannagari. "Discrete Optimization for Supply Demand Matching in Smart Grids". PhD thesis. University of Southern California, 2018.

[SUST18a] Athanasios A Rompokos, Sanmukh R Kuppannagari, Rajgopal Kannan, and Viktor K Prasanna. "Minimizing Cost of Load Matching in Multiple Micro-Grids Using MESS". In: *2018 IEEE Conference on Technologies for Sustainability (SusTech)*. IEEE. 2018, pp. 1–7.

[SGCOMM18] Chi Zhang, Sanmukh R Kuppannagari, Rajgopal Kannan, and Viktor K Prasanna. "Generative adversarial network for synthetic time series data generation in smart grids". In: *2018 IEEE International Conference on Communications, Control, and Computing Technologies for Smart Grids (SmartGridComm)*. IEEE. 2018, pp. 1–6.

[BuildSys17] Sanmukh R Kuppannagari, Rajgopal Kannan, and Viktor K Prasanna. "Optimal net-load balancing in smart grids with high PV penetration". In: *Proceedings of the 4th ACM International Conference on Systems for Energy-Efficient Built Environments*. ACM. 2017, p. 27.

[IJCAI16] Sanmukh R Kuppannagari, Rajgopal Kannan, Charalampos Chelmis, and Viktor K Prasanna. "Implementation of Learning-Based Dynamic Demand Response on a Campus Micro-Grid". In: *The 25th International Joint Conference on Artificial Intelligence*. IJCAI-Demo Track. 2016.

[ICCS16] Sanmukh R Kuppannagari, Rajgopal Kannan, Charalampos Chelmis, Arash S Tehrani, and Viktor K Prasanna. "Optimal Customer Targeting for Sustainable Demand Response in Smart Grids". In: *Procedia Computer Science* 80 (2016), pp. 324–334.

[SUST16] Charith Wickramaarachchi, Sanmukh R Kuppannagari, Rajgopal Kannan, and Viktor K Prasanna. "Improved protection scheme for data attack on strategic buses

in the smart grid". In: *2016 IEEE Conference on Technologies for Sustainability (SusTech)*. IEEE. 2016, pp. 96–101.

[CSCI15] Sanmukh R Kuppannagari, Rajgopal Kannan, and Viktor K Prasanna. "An ILP based Algorithm for Optimal Customer Selection for Demand Response in SmartGrids". In: *The 2015 International Conference on Computational Science and Computational Intelligence (CSCI)*. 2015.

## Other

[FPGA20] Rachit Rajat, Yuan Meng, Sanmukh R Kuppannagari, Ajitesh Srivastava, Rajgopal Kannan, and Viktor K Prasanna. "QTAccel: Generic FPGA Design for Q-Table based Reinforcement Learning Accelerators". In: *Proceedings of the 2020 ACM/SIGDA International Symposium on Field-Programmable Gate Arrays*. To Appear. Abstract Only. ACM. 2020.

[ISC20] Yang Yang, Sanmukh R Kuppannagari, Ajitesh Srivastava, Rajgopal Kannan, and Viktor K Prasanna. "FASTHash: FPGA-based High Throughput Parallel Hash Table". In: *ISC High Performance 2020*. Under Review. 2020.

[ParFPGA19] Akshit Goel, Sanmukh R Kuppannagari, Yang Yang, Ajitesh Srivastava, and Viktor K Prasanna. "Parallel Totally Induced Edge Sampling on FPGAs". In: *Parallel Computing with FPGAS (ParFPGA2019)*. 2019.

[HPEC19] Sanmukh R Kuppannagari, Rachit Rajat, Rajgopal Kannan, Aravind Dasu, and Viktor K Prasanna. "IP Cores for Graph Kernels on FPGAs". In: *2019 IEEE High Performance Extreme Computing Conference (HPEC)*. IEEE. 2019.

[FPGA15] Sanmukh R Kuppannagari and Viktor K Prasanna. "Efficient Generation of Energy and Performance Pareto Front for FPGA Designs". In: *Proceedings of the 2015 ACM/SIGDA International Symposium on Field-Programmable Gate Arrays*. Abstract Only. ACM. 2015, pp. 273–273.

[HPEC14] Sanmukh R Kuppannagari, Ren Chen, Andrea Sanny, Shreyas G Singapura, Geoffrey Phi C Tran, Shijie Zhou, Yusong Hu, Stephen P Crago, and Viktor K Prasanna. "Energy performance of fpgas on perfect suite kernels". In: *2014 IEEE High Performance Extreme Computing Conference (HPEC)*. IEEE. 2014, pp. 1–6.

[IGCC14] Sanmukh R Kuppannagari, Yusong Hu, and Viktor K Prasanna. "High level performance model based design space exploration for energy-efficient designs on fpgas". In: *International Green Computing Conference*. IEEE. 2014, pp. 1–6.