

Anand Balakrishnan

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EDUCATION

- **Ph.D. Computer Science** Aug 2019 — Ongoing
University of Southern California
Advisor: *Jyotirmoy V. Deshmukh*
- **B.S. Computer Engineering** May 2018
University at Buffalo
Distinction: *Magna Cum Laude*

EXPERIENCE

- **Research Assistant** Aug 2018 — Ongoing
CPS-VIDA Group, University of Southern California
Advisor: *Jyotirmoy V. Deshmukh*
- **Technical Intern** June 2023 — Aug 2023
Siemens Corporation
- **Teaching Assistant** Fall 2021
CSCI 513: Autonomous Cyber-Physical Systems
Course Instructor: *Jyotirmoy V. Deshmukh*
- **ADAS Software Engineering Intern** June 2021 — Aug 2021
INDI EV, Inc.
- **Research Intern** May 2020 — Aug 2020
Toyota Research Institute, North America
- **Undergraduate Researcher** Feb 2016 — May 2018
Distributed Robotics and Networked Embedded Systems Lab, University at Buffalo
Advisor: *Karthik Dantu*
- **Undergraduate Teaching Assistant** Fall 2017
CSE331: Algorithm Analysis and Design, University at Buffalo
Course Instructor: *Atri Rudra*

PUBLICATIONS

Journals and Conferences

- A. Balakrishnan, S. Jaksic, E. A. Aguilar, D. Nickovic, and J. Deshmukh, “Model-free Reinforcement Learning for Spatiotemporal Tasks using Symbolic Automata,” in *62nd IEEE Conference on Decision and Control (CDC)*, Invited Paper, Accepted, Dec. 2023.
- A. Balakrishnan, J. Deshmukh, B. Hoxha, T. Yamaguchi, and G. Fainekos, “PerceMon: Online Monitoring for Perception Systems,” in *Runtime Verification*, L. Feng and D. Fisman, Eds., ser. Lecture Notes in Computer Science, Cham: Springer International Publishing, Oct. 2021, pp. 297–308, ISBN: 978-3-030-88494-9. DOI: 10.1007/978-3-030-88494-9_18.

- Z. S. Hashemifar, C. Adhivarahan, A. Balakrishnan, and K. Dantu, “Augmenting Visual SLAM with Wi-Fi Sensing for Indoor Applications,” *Autonomous Robots*, vol. 43, no. 8, pp. 2245–2260, Dec. 2019, ISSN: 1573-7527. DOI: 10.1007/s10514-019-09874-z.
- A. Balakrishnan and J. V. Deshmukh, “Structured Reward Shaping Using Signal Temporal Logic Specifications,” in *2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, Nov. 2019, pp. 3481–3486. DOI: 10.1109/IROS40897.2019.8968254.
- A. Balakrishnan, A. G. Puranic, X. Qin, *et al.*, “Specifying and Evaluating Quality Metrics for Vision-Based Perception Systems,” in *2019 Design, Automation Test in Europe Conference Exhibition (DATE)*, Mar. 2019, pp. 1433–1438. DOI: 10.23919/DATE.2019.8715114.

Preprints

- A. Balakrishnan, S. Jaksic, E. A. Aguilar, D. Nickovic, and J. Deshmukh, “Model-Free Reinforcement Learning for Symbolic Automata-encoded Objectives,” *arXiv:2202.02404 [cs]*, Feb. 2022. arXiv: 2202.02404 [cs].
- P. Kapoor, A. Balakrishnan, and J. V. Deshmukh. “Model-Based Reinforcement Learning from Signal Temporal Logic Specifications.” arXiv: 2011.04950 [cs, eess]. (Nov. 2020).
- K. Nottingham, A. Balakrishnan, J. Deshmukh, C. Christopherson, and D. Wingate. “Using Logical Specifications of Objectives in Multi- Objective Reinforcement Learning.” arXiv: 1910.01723 [cs, stat]. (Oct. 2019).

Posters and Presentations

- A. Balakrishnan, S. Jaksic, E. A. Aguilar, D. Nickovic, and J. Deshmukh, “Poster Abstract: Model-Free Reinforcement Learning for Symbolic Automata-encoded Objectives,” in *25th ACM International Conference on Hybrid Systems: Computation and Control*, ser. HSCC ’22, New York, NY, USA: Association for Computing Machinery, May 4, 2022, pp. 1–2, ISBN: 978-1-4503-9196-2. DOI: 10.1145/3501710.3524734.
- A. Balakrishnan and J. V. Deshmukh, “Structured Reward Functions Using STL: Poster Abstract,” in *Proceedings of the 22nd ACM International Conference on Hybrid Systems: Computation and Control*, ser. HSCC ’19, New York, NY, USA: Association for Computing Machinery, Apr. 2019, pp. 270–271, ISBN: 978-1-4503-6282-5. DOI: 10.1145/3302504.3313355.
- A. Balakrishnan, P. Behara, Z. Hashemifar, and K. Dantu, “Poster: Dataset for Experimental Validation of Wi-Fi Sensing,” in *6th Annual Northeastern Robotics Colloquium*, ser. NERC ’17, Boston, MA, USA, Oct. 2017.

Unpublished/Work-in-progress

- A. Balakrishnan, J. Deshmukh, and A. Trivedi, “Timed deep reinforcement learning.”
- A. Balakrishnan, Y. Gajjar, X. Qin, *et al.*, “Spatio-temporal monitoring of tracking algorithms in autonomous driving systems.”

VOLUNTEERING AND SERVICES

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|-------------------|--|------|
| • Reviewer | IEEE Transactions on Robotics | T-RO |
| • Reviewer | IEEE Robotics and Automation Letters | RA-L |
| • Reviewer | Transactions on Cyber-Physical Systems | TCPS |

- **Reviewer** ACM International Conference on Hybrid Systems: Computation and Control HSCC 2024
- **Reviewer** International Conference on Verification, Model Checking, and Abstract Interpretation VMCAI 2024
- **Reviewer** International Conference on Runtime Verification RV 2023
- **Reviewer** IEEE Conference on Decision and Control CDC 2022
- **Reviewer** IEEE/RSJ International Conference on Intelligent Robots and Systems IROS 2022
- **Reviewer** IEEE International Conference on Robotics and Automation ICRA 2022
- **Reviewer** IEEE/RSJ International Conference on Intelligent Robots and Systems IROS 2021
- **Reviewer** Design Automation Conference DAC 2021
- **Volunteer Organizer** International Conference on Runtime Verification RV 2020
- **Reviewer** IEEE Conference on Decision and Control CDC 2020
- **Reviewer** International Conference on Intelligent Robots and Systems IROS 2020
- **Repeatability Evaluator** ACM International Conference on Hybrid Systems: Computation and Control HSCC 2020
- **Graduate Mentor** SURE Program: Summer Research for Undergraduates Summer 2019
- **Reviewer** International Conference on Cyber-Physical Systems ICCPS 2019

RESEARCH

Logical Specification-Guided Reinforcement Learning

CPS-VIDA Group, University of Southern California

- Investigate use of Temporal Logics in the training and validation of safe reinforcement learning agents.
- Developed a method of using Signal Temporal Logic formulas and a choice of quantitative semantics to produce rewards for reinforcement learning agents from finite length signal traces.
- Extend this for use in reinforcement learning scenarios with multiple objectives.

Monitoring and logical decision-making for multi-modal data streams

CPS-VIDA Group, University of Southern California

Siemens Corporation

- Develop logical consistency checkers for streams of data originating from multiple different sensor modalities, especially visual sensors.

Safety evaluation and monitoring of perception algorithms

CPS-VIDA Group, University of Southern California

Toyota Research Institute, North America

- Develop monitoring algorithms for data streams that are generated by perception algorithms like object tracking and object detection.
- Developed a toolbox to specify logical specifications on perception algorithms and monitor their output when run on various datasets.
- Develop algorithm and tool to efficiently monitor perception algorithms at runtime.

Wi-Fi Augmented Sensing

Distributed Robotics and Networked Embedded Systems Lab, University at Buffalo

- Compile a dataset that incorporates streams of depth images (RGB-D) along with Wi-Fi data for development of simultaneous localization and mapping (SLAM) algorithms that are augmented with Wi-Fi.
- Deploy ROS-based system to collect the relevant data, and to test the performance of Wi-Fi augmented SLAM algorithms.

RELATED PROJECTS

Argus

[GitHub:anand-bala/argus]

- Using: Rust, Python
- A Rust library (with Python bindings) for efficiently working with Signal Temporal Logic (STL) and its quantitative semantics.

PerceMon

[GitHub:anand-bala/PerceMon]

- Using: C++
- A tool for online monitoring of Spatio-Temporal Quality Logic specifications.
- The logic is used to generate monitors for topological entities in streams of perception data.

Symbolic Automata Monitors

[GitHub:anand-bala/symbolic-automata-monitors]

- Using: Python
- A library for creating and manipulating symbolic automata.
- Used to define runtime monitors using various algebraic semirings.

Signal Temporal Logic Library

[GitHub:anand-bala/signal-temporal-logic]

- Using: C++, Python
- A library for efficiently working with Signal Temporal Logic (STL) and its quantitative semantics.

Probabilistic Timed Automata Library

[GitHub:anand-bala/probabilistic-timed-automata]

- Using: Python
- Python library for building and simulating probabilistic timed automata.

Persephone

[GitHub:cps-vida/Persephone]

- Using: Matlab, C
- A MATLAB toolbox to monitor data streams generated by perception systems.
- Uses Timed Quality Temporal Logic specifications to build monitors for perception algorithms, including object tracking, bounding box detection, etc.