Somil Bansal

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AFFILIATION | **University of Southern California** | Fall 2021 -
Assistant Professor, Ming Hsieh Department of Electrical and Computer Engineering

RESEARCH INTERESTS

I am interested in the intersection of control and dynamical system theory, machine learning, and computer vision for robotic applications.

During my Ph.D., I developed new data-efficient and provably safe learning-based control algorithms for the goal of *safe* and *intelligent* autonomous systems. My approach brings together tools from control theory, machine learning, and computer vision to design systems that possess the ability to learn, improve, and adapt in unknown and dynamic environments in a data-efficient fashion. At the same time, these systems can actively reason about safety and take action to preserve it when necessary. My key research contributions are:

1. **Data-efficient task-based learning using models and optimal control:** developing optimal control-based learning frameworks for efficiently completing a given control task in hard-to-model environments.

2. **Data-efficient architectures for learning-based perception with model-based control:** developing perception-action loops that efficiently combine deep learning-based perception with an underlying dynamics model for control, such as to navigate in *a priori* unknown environments.

3. **Advancing the theory of optimal control for scalable safety analysis of learning-enabled systems:** introducing new formulations and computational tools to enable run-time safety assurance for learning-enabled systems, including large-scale multi-agents systems.

4. **Safety assurance for learning-enabled systems in unknown and human-centric environments:** using the above tools to construct safety envelopes around learning-based perception and human motion prediction components, allowing robust motion plans to avoid collisions with obstacles and humans.

EDUCATION | **University of California, Berkeley** | 2015 - 2020
Ph.D. in Electrical Engineering and Computer Sciences
Advisor: Claire Tomlin
CGPA : 4.0/4.0

University of California, Berkeley | 2012 - 2014
MS in Electrical Engineering
Advisor: Claire Tomlin
CGPA : 4.0/4.0

Indian Institute of Technology, Kanpur | 2008 - 2012
B.Tech. in Electrical Engineering
CGPA : 9.8/10

WORK
EXPERIENCE

Waymo, Mountain View   September 2020 - Present
Research Scientist

Skydio, Redwood City   May 2018 - Aug 2018
Computer Vision and Planning Intern
Developed and experimentally evaluated algorithms that combine machine learning and planning for autonomous drone navigation in *a priori* unknown environments.

Applied Predictive Technologies, San Francisco   Aug 2014 - Sep 2015
Business Consultant
Led data-driven analyses to design business initiatives/promotions and to forecast their performance.

Broadcom, Sunnyvale   Summer 2013
Performance Engineering Intern
Conducted quantitative analyses to identify performance bottlenecks in existing products.

University of Western Ontario, London, Canada   Summer 2011
Research Intern
Proposed a novel approach for vector-fitting in the presence of noise for high-frequency applications.

AWARDS
& HONORS

Eli Jury Award   Department of EECS, UC Berkeley, 2020
"For outstanding achievement in the area of systems, communications, control, or signal processing."

Selected for **RSS Pioneers**   RSS, 2019
"A workshop to bring together a cohort of the world's top early career researchers in robotics."

Outstanding Graduate Student Instructor Award   UC Berkeley, 2019
Awarded to up to 10% of current teaching assistants throughout the university.

Graduate Student Gold Fellowship   Department of EECS, UC Berkeley, 2013

Excellence Award in Community Services   IIT Kanpur, 2012
"Recognizing the graduating student with outstanding work in various aspected of community services."

Academic Excellence Award (Dean's List)   IIT Kanpur, 2010, 2011.

MITACS Globalink Fellowship   IIT Kanpur, 2011
For undergraduate research at University of Western Ontario, London, Canada.

Amit Saxena Memorial Award   IIT Kanpur, 2011
Awarded to the UG student of EE department having the highest score in the courses related to electronics circuits.

TEACHING
EXPERIENCE

EE221A: Linear System Theory   UC Berkeley, Fall 2016, 2018
Graduate Student Instructor
Received the *Outstanding Graduate Student Instructor Award.*

MTH101: Introduction to Real Analysis and Calculus   IIT Kanpur, Fall 2009, 2010
Academic Mentor

MTH102: Basics of Complex Analysis and Linear Algebra   IIT Kanpur, Spring 2010, 2011
Academic Mentor

LEADERSHIP
& SERVICE

Workshop Organizer
RSS 2019, 2020: Robust Autonomy: Safe Robot Learning and Control in Uncertain Real-World Environments.

Tutorial Organizer
CDC 2017: Hamilton-Jacobi Reachability: A Brief Overview and Recent Advances.
UC Berkeley 2016: Introduction to Hamilton-Jacobi Reachability.

DREAM Seminar Organizer   2017-2019
Design of Robotics and Embedded systems, Analysis, and Modeling Seminar (DREAMS)

External Reviewer for Conferences and Journals
Control Theory: CDC 2015-19, ACC 2015-19, HSCC 2019, ICCPS 2019,
L-CSS 2018, TAC 2017-19
Machine Learning and Robotics: CoRL 2017-19, IROS 2018-19, ICRA 2018-19,
RSS 2019, JMLR 2018, RA-L 2018-19, T-RO 2018-19

Program Committee
HSCC 2020

RESEARCH
MENTORSHIP

Masters Students
- Varun Tolani (UC Berkeley EECS, MSc, 2018), Research assistant at UC Berkeley.
- Anjian Li (Simon Fraser University CS, MSc, 2019).
- Ted Xiao (UC Berkeley EECS, MSc, 2017), Researcher at Google Brain.

Undergraduate Students
- Khalil Sarwari (UC Berkeley EECS Undergraduate, 2019).
- Lucas Medino (UC Berkeley EECS, Visiting Researcher, 2019).
- Eli Bronstein (UC Berkeley EECS Undergraduate, 2019), Symbio Robotics.
- Nathan Blair (UC Berkeley EECS Undergraduate, 2018-2019).
- Jonathan Lee (UC Berkeley EECS Undergraduate, 2017-2018), PhD student at Stanford.
- Frank Jiang (UC Berkeley EECS Undergraduate, 2015-2016), PhD student at KTH Royal Institute of Technology, Sweden.

INVITED
TALKS

Safe and Data-Efficient Learning for Robotics
Google Robotics Seminar, 2020.

Scaling Hamilton-Jacobi Reachability Analysis for Robotics: Multi-agent Systems to Real-time Computation
Institute for Pure & Applied Mathematics (IPAM), 2020.

Safe and Data-Efficient Learning for Robotics
Yale University, Department of Mechanical Engineering and Materials Science, 2020.
Georgia Tech University, School of Electrical and Computer Engineering, 2020.
Cornell University, Department of Electrical and Computer Engineering, 2020.
Cornell University, Department of Computer Science, 2020.
Harvard University, School of Engineering And Applied Sciences, 2020.
University of British Columbia, Department of Computer Science, 2020.
University of Southern California, Department of Electrical and Computer Engineering, 2020.

Safe Learning-Enabled Decision Making for Robotics in Novel Environments
ETH Zurich, Department of Mechanical and Process Engineering, 2019.

Safe Learning-Enabled Decision Making for Autonomous Navigation in Novel Environments
University of Toronto, UTIAS, 2019.
CITRIS/CPAR Control Theory and Automation Symposium, 2019.
Workshop on Algorithms and Architectures for Learning-in-the-loop Systems in Autonomous Flight, ICRA 2019.

Combining Optimal Control and Learning for Visual Navigation in Novel Environments
Simons Institute Annual Industry Day, 2019.

Deep Learning Quadrotor Dynamics for Flight Control
CITRIS-Honeywell Drones: Technology, Policy and Society Conference, 2018.

Overcoming Model Bias in Model-Based Learning
Berkeley Artificial Intelligence/ Berkeley Deep Drive Workshop, UC Berkeley, 2016.

OUTREACH **Girls in Engineering Camp**   UC Berkeley, 2019
A week-long, non-residential summer camp for San Francisco Bay Area students entering 6th, 7th, and 8th grades to explore different aspects of what it means to be an engineer.

Inclusion@RSS   RSS, 2019
Mentored several early career graduate students who belong to traditionally underrepresented groups in robotics.

Berkeley School Volunteers   Berkeley, 2017-2018
Volunteer teacher for middle school students in public schools.

National Social Service Volunteer (Prayas Program)   IIT Kanpur, 2008-2012
Taught underrepresented and underprivileged K-12 students who could not afford quality education. I was awarded the **IIT Kanpur excellence award in community services** for my efforts.

PEER-REVIEWED
CONFERENCE
PUBLICATIONS
Visual Navigation Among Humans with Optimal Control as a Supervisor
Varun Tolani, *Somil Bansal*, Aleksandra Faust, Claire J. Tomlin
arXiv Preprint, 2020 (under review)

A Hamilton-Jacobi Reachability-Based Framework for Predicting and Analyzing Human Motion for Safe Planning
Somil Bansal, Andrea Bajcsy, Ellis Ratner, Anca D. Dragan, Claire J. Tomlin
International Conference on Robotics and Automation (ICRA), 2020

Generating Robust Supervision for Learning-Based Visual Navigation Using Hamilton-Jacobi Reachability
Anjian Li, *Somil Bansal*, Georgios Giovanis, Varun Tolani, Claire J. Tomlin, Mo Chen
Conference on Learning for Dynamics and Control (L4DC), 2020

Combining Optimal Control and Learning for Visual Navigation in Novel Environments
Somil Bansal, Varun Tolani, Saurabh Gupta, Jitendra Malik, Claire J. Tomlin
Conference on Robot Learning (CoRL), 2019

An Efficient Reachability-Based Framework for Provably Safe Autonomous Navigation in Unknown Environments
Andrea Bajcsy, *Somil Bansal*, Eli Bronstein, Varun Tolani, Claire J. Tomlin
IEEE Conference on Decision and Control (CDC), 2019

Reachability-Based Safety Guarantees Using Efficient Initializations
Sylvia Herbert, *Somil Bansal*, Shromona Ghosh, Claire J. Tomlin

IEEE Conference on Decision and Control (CDC), 2019

Closed-Loop Model Selection for Kernel-based Models Using Bayesian Optimization
Thomas Beckers, **Somil Bansal**, Claire J. Tomlin, Sandra Hirche
IEEE Conference on Decision and Control (CDC), 2019

A New Simulation Metric to Determine Safe Environments and Controllers for Systems with Unknown Dynamics
Shromona Ghosh, **Somil Bansal**, Alberto Sangiovanni-Vincentelli, Sanjit Seshia, Claire Tomlin
ACM International Conference on Hybrid Systems: Computation and Control (HSCC), 2019

Goal-Driven Dynamics Learning via Bayesian Optimization
Somil Bansal, Roberto Calandra, Ted Xiao, Sergey Levine, Claire Tomlin
IEEE Conference on Decision and Control (CDC), 2017

Hamilton-Jacobi Reachability: A Brief Overview and Recent Advances
Somil Bansal, Mo Chen, Sylvia Herbert, Claire Tomlin
IEEE Conference on Decision and Control (CDC), 2017

FaSTrack: a Modular Framework for Fast and Guaranteed Safe Motion Planning
Sylvia Herbert, Mo Chen, Soojean Han, **Somil Bansal**, Jaime F. Fisac, Claire Tomlin
IEEE Conference on Decision and Control (CDC), 2017

Safe Sequential Path Planning of Multi-Vehicle Systems Under Disturbances and Imperfect Information
Somil Bansal, Mo Chen, Jaime F. Fisac, Claire Tomlin
American Control Conference (ACC), 2017

Learning Quadrotor Dynamics Using Neural Network for Flight Control
Somil Bansal, Anayo K. Akametalu, Frank Jiang, Forrest Laine, Claire Tomlin
IEEE Conference on Decision and Control (CDC), 2016

Plug-and-Play Model Predictive Control for Electrical Vehicle Charging and Voltage Control in Smart Grids
Somil Bansal, Melanie Zeilinger, Claire Tomlin
IEEE Conference on Decision and Control (CDC), 2014

JOURNAL
PUBLICATIONS

Provably Safe and Scalable Multi-Vehicle Trajectory Planning
Somil Bansal, Mo Chen, Ken Tanabe, Claire Tomlin
IEEE Transactions on Control Systems Technology (TCST) (under review)

SPEC: An Approach to Determine Safe Environments and Controllers for Systems with Unknown Dynamics
Somil Bansal, Shromona Ghosh, Alberto Sangiovanni-Vincentelli, Sanjit Seshia, Claire Tomlin
IEEE Transactions on Automatic Control (TAC) (in prepration)

FaSTrack: a Modular Framework for Real-Time Motion Planning and Guaranteed Safe Tracking
Mo Chen, Sylvia Herbert, Haimin Hu, Ye Pu, Jaime F. Fisac, **Somil Bansal**, SooJean Han, Claire Tomlin
IEEE Transactions on Automatic Control (TAC), 2020

Robust Sequential Path Planning Under Disturbances and Adversarial Intruder
Mo Chen, **Somil Bansal**, Jaime F. Fisac, Claire Tomlin
IEEE Transactions on Control Systems Technology (TCST), 2017

Decomposition of Reachable Sets and Tubes for a Class of Nonlinear Systems

Mo Chen, Sylvia Herbert, Mahesh Vashishtha, ***Somil Bansal***, Claire Tomlin
IEEE Transactions on Automatic Control (TAC), 2017

Plug-and-Play Model Predictive Control for Load Shaping and Voltage Control in Smart Grids
Caroline L. Floch, ***Somil Bansal***, Claire Tomlin, Scott Moura, Melanie Zeilinger
IEEE Transactions on Smart Grid, 2017

BOOK CHAPTERS

Control and Safety of Autonomous Vehicles with Learning-Enabled Components
Somil Bansal, Claire Tomlin
Safe, Autonomous and Intelligent Vehicles, Springer, Page 57-75, 2019.

WORKSHOP PUBLICATIONS

Combining Optimal Control and Learning for Visual Navigation in Novel Environments
Somil Bansal, Varun Tolani, Saurabh Gupta, Jitendra Malik, Claire Tomlin
Workshop on Deep Learning for Visual Navigation
Conference on Computer Vision and Pattern Recognition (CVPR), 2019

Safe Learning-Enabled Decision Making for Autonomous Navigation in Novel Environments
Somil Bansal, Claire Tomlin
Workshop on Algorithms and Architectures for Learning-in-the-loop Systems in Autonomous Flight
International Conference on Robotics and Automation (ICRA), 2019

Advancing the Runtime of Hamilton-Jacobi Reachability Analysis
Somil Bansal, Claire Tomlin
Workshop on Towards Online Optimal Control of Dynamic Robots
International Conference on Robotics and Automation (ICRA), 2019

TECHNICAL REPORTS

Context-Specific Validation of Data-Driven Models
Somil Bansal, Shromona Ghosh, Alberto Sangiovanni-Vincentelli, Sanjit Seshia, Claire Tomlin
Technical report, March 2018

Safe and Resilient Multi-vehicle Trajectory Planning Under Adversarial Intruder
Somil Bansal, Mo Chen, Claire Tomlin
Technical report, November 2017

MBMF: Model-Based Priors for Model-Free Reinforcement Learning
Somil Bansal, Roberto Calandra, Kurtland Chua, Sergey Levine, Claire Tomlin
Technical report, June 2017