

Raj Deshmukh

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EDUCATION

Purdue University, West Lafayette

Ph.D., Aeronautics and Astronautics Engineering, expected May 2020 GPA: 3.72/4.00
Dissertation: Data-driven Learning for Anomaly Detection and Prognosis in Terminal Airspace Operations

Major: Dynamics and Control, *Minor*: Systems Engineering

M.S., Aeronautics and Astronautics Engineering, 2017

GPA: 4.00/4.00

Thesis: Development of Optimal Kalman Consensus Filter and its Application to Distributed Hybrid State Estimation

Major: Dynamics and Control, *Minor*: Systems Engineering

Indian Institute of Technology Kharagpur, India

B.Tech. with Honors, Aerospace Engineering, 2015

GPA: 8.49/10.00

Thesis: Automatic Control of VTOL UAV

Minor: Electronics & Electrical Communication Engineering

Graduated top of class with **University Silver Medal**

RESEARCH AREAS

• Machine learning • Predictive analysis • Multi-sensor fusion • Data fusion • Hybrid system theory • Distributed state estimation theory • Probability and statistics • Expressive data modeling • Physics/dynamics-based modeling • Airspace operations • Autonomous navigation • Network-based operations • Graph theory • Iterative testing and test-bed deployment

PUBLICATIONS

Deshmukh, Raj, et al. "Distributed State Estimation for a Stochastic Linear Hybrid System over a Sensor Network." *IET Control Theory & Applications* 12.10 (2018): 1456-1464.

Deshmukh, Raj, and Inseok Hwang. "Incremental-Learning-Based Unsupervised Anomaly Detection Algorithm for Terminal Airspace Operations." *Journal of Aerospace Information Systems* (2019).

Deshmukh, Raj, et al. "Reactive Temporal Logic-Based Precursor Detection Algorithm for Terminal Airspace Operations." *Journal of Air Transportation* 28.4 (2020): 155-163.

Deshmukh, Raj, Cheolhyeon Kwon, and Inseok Hwang. "Optimal Discrete-time Kalman Consensus Filter." *2017 American Control Conference (ACC)*. IEEE, 2017.

Deshmukh, Raj, and Inseok Hwang. "Anomaly Detection Using Temporal Logic Based Learning for Terminal Airspace Operations." *AIAA Scitech 2019 Forum* (Finalist for Best Student Paper).

Deshmukh, Raj, Dawei Sun, and Inseok Hwang. "Data-Driven Precursor Detection Algorithm for Terminal Airspace Operations." *FAA/Eurocontrol ATM Seminar 2019* (Best paper in Complexity track).

Khan, Shiraz, **Raj Deshmukh**, and Inseok Hwang. "Optimal Kalman Consensus Filter for Weighted Directed Graphs." *2019 IEEE 58th Conference on Decision and Control (CDC)*. IEEE, 2019.

Deshmukh, Raj, et al. "Temporal Logic Learning-based Anomaly Detection in Metroplex Terminal Airspace Operations." *Transportation Research: Part C* (2019), under review.

Kim, Kwangyeon, **Raj Deshmukh**, and Inseok Hwang. "Development of Data-Driven Conflict Resolution Generator for En-Route Airspace" *Aerospace Science and Technology* (2019), under review.

Deshmukh, Raj, et al. "Enhancing the Effectiveness of Network Centric Operations using System-of-Systems Modeling and Analysis Technique." Presentation at *10th Annual Conference of the Asia-Pacific Council on Systems Engineering* (2016).

RESEARCH PROJECTS

Purdue University, West Lafayette

Purdue Flight Dynamics & Control/Hybrid Systems Lab

• Optimal Distributed State Estimation

Aug '15 - Jan '20

- Addressed decade-long problem of suboptimality in Kalman consensus filtering, finding applications in sensor network theory and network fault detection
- Developed optimal Kalman consensus filter applied to stochastic LTI and hybrid targets; documented as master's thesis, with advisor Dr. Inseok Hwang
- Extended application of distributed state estimation to network with naïve sensors

- Currently working on measurement vector fusion, enabling consensus on measurements as well as estimates; and on proving algorithm stability
- **NASA Big Data Analytics Project** Nov '17 - Sep '19
 - Investigated use of data-driven methods to discover previously unknown safety threats within extremely large, heterogeneous datasets representing operations of the National Airspace System
 - Designed and implemented machine learning-based anomaly detection and prognosis algorithms to detect operational and safety related issues using real air traffic datasets recorded at LGA, JFK and EWR airports in New York metroplex
 - Contributed to development of a rapidly deployable, scalable, and versatile air traffic management (ATM) simulation and test environment along with Mosaic ATM and Honeywell International Inc., helping advance decision-making capabilities to improve ATM on a grand scale
 - Contributions to project documented as doctoral dissertation, with advisor Dr. Inseok Hwang
- **NASA Next-Gen Concept Technology and Development Project** May '16 - Oct '17
 - Investigated methods to identify and classify resolutions for detected conflicts in historical aircraft track data, collaborating with Optimal Synthesis Inc.
 - Designed novel hierarchical supervised learning algorithm employed within decision-aiding tool to generate conflict resolution strategies learned from flight plans and historical track data
- **Relaxation of Min-max Strategies to Control Autonomous Vehicles** Jan '16 - May '16
 - Investigated into a dynamically evolving balance between performance and safety of connected autonomous ground vehicles, characterized by likelihood of collision, as a novel extension to conventional min-max navigation strategies

National Aerospace Laboratories, India

May '14 - Jul '14

Flight Mechanics and Control Division

- **Drag Polar Estimation of a High Performance Aircraft Using Crash Data Recorder**
 - Undertook performance analysis of fly-by-wire aircraft using parameter estimation techniques
 - Lift, drag, and pitching characteristics were estimated using model-based and non-model-based approaches using flight test data recorded in crash data recorder

IIT Kharagpur, India

Boeing Company, U.S.A.

- **Phase 6 Boeing Students' Project** Mar '14 - Feb '15
 - Project requiring design, fabrication, and testing of semi-autonomous quadrotor capable of waypoint navigation
- **Phase 5 Boeing Students' Project** Mar '13 - Feb '14
 - Project involving design and flight testing of micro-air vehicle capable of waypoint navigation
 - Designed novel wing planform with winglets using flying wing configuration

SKILLS

- Programming languages and scientific software: MATLAB, C, Python, R, Simulink, SolidWorks
- Documentation and technical writing: L^AT_EX, MS Office

WORK EXPERIENCE

Graduate Research Assistant

Aug '15 - Jul '17 & Jun '18 - Sep '19

Graduate Teaching Assistant

Aug '17 - May '18 & Aug '19 - Dec '19

- Collaborated with supervisors and colleagues for designing course instruction materials for sophomore and junior undergraduate students
- Maintained webcourses on Blackboard, a digital instruction platform
- Consistently provided feedback on assignments during weekly office hours, proctored and graded exams, entered and maintained grades, and provided review preparation for final exam

SCHOLASTIC HONORS

University Silver Medal

Awarded university silver medal for graduating at top of undergraduate class

Jagadis Bose Scholar

Scholarship by Jagadis Bose National Science Talent Search; aims to identify and nurture young talented students of science, medicine and engineering with potential to become leaders in innovation excellence; one among 55 scholars in India