# Raj Deshmukh

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## EDUCATION

**Purdue University, West Lafayette**
***Ph.D.***, Aeronautics and Astronautics Engineering, 2020 GPA: 3.65/4.00
*Dissertation*: Data-driven Learning for Anomaly and Precursor Detection in Metroplex 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

• Multi-sensor fusion • Multi-target tracking • Hybrid system theory • Distributed state estimation • Probability and statistics • Automotive systems • Machine learning • Predictive analysis • 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.

Khan, Shiraz, **Raj Deshmukh**, and Inseok Hwang. "Optimal Kalman Filter with Information-Weighted Consensus." *IEEE Transactions on Automatic Control* (2020), 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).

## WORK EXPERIENCE

**Aptiv, Troy**
*Active Safety & User Experience*

- **Object Tracking Developer** Mar '20 - *present*
  - Responsible for designing and implementing production-level automotive perception algorithms that use radar and camera sensors for multi-sensor multi-target data fusion
  - Implementing object tracking to enable advanced-driver assistance systems (ADAS) features designed for OEMs, and helped root-cause and resolve issues found by OEMs during real-world testing
  - Developing sensor monitoring algorithms that safely disable ADAS features upon loss of signal quality by ascertaining their plausibility before perception-related processing
  - Ensuring industry-related quality assurance by running functional tests for ASPICE and MISRA compliance

**Purdue University, West Lafayette**
*School of Aeronautics and Astronautics*

- **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

## 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 Prof. Inseok Hwang
  - Extended application of distributed state estimation to network with naïve sensors
  - Developed measurement vector fusion approach, enabling consensus on measurements as well as estimates
- **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 Prof. 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: LaTeX, MS Office, Polarion

## 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