Dr. RICHA SINGH

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WORK EXPERIENCE [July 2022 - Present]

I am an Application Engineer at MathWorks in Hyderabad, India. I specialize in empowering both commercial and government customers to forge innovative aerospace and defense solutions. My journey in this domain is fueled by a passion for merging theoretical knowledge with practical applications, particularly in control design and automation for aerospace applications. In this role I am responsible for:

- The objective is to understand customers' challenges and provide them with solutions to accelerate their development process.
- Work closely with sales, marketing, and product development teams to align customer needs with MathWorks product offerings and roadmaps.
- Provide customers with a tailored solution for optimizing the control algorithms of an autonomous vehicle.
- Represent MathWorks at industry conferences, workshops, and seminars, sharing insights and best practices in control design automation.
- Develop resources such as webinars, and tutorials to provide ongoing support and education to the aerospace community.on Aerospace systems and subsystems.

EDUCATION

2015 – 2022	M.Tech. + Ph.D. in Aerospace Engineering Specialization: Dynamics and Controls Indian Institute of Technology Bombay
2010 – 2014	Bachelor in Aeronautical Engineering Aeronautical Society of India, New Delhi

RESEARCH INTERESTS

Primary topics of research include, but are not limited to: Gas Turbine Engine Modeling and Control, Robust Nonlinear Control, Fault Tolerance and Estimation based Control, Adaptive Distributed Estimation, Machine Learning and Deep Learning Applications to Gas Turbine Engine, Reinforcement Learning Control, end-to-end workflow for Autonomous systems, Motor control algorithms.

DOCTORAL THESIS

Modeling, Simulation and Control of a Laboratory Gas Turbine Engine
Guide: Prof. Arnab Maithy, Co-guide: Prof. P. S. V. Nataraj [Sept 2021]

- Proposed a **State Variable Method** to derive a steady-state and transient model dynamics of a laboratory engine, and **validated the developed mathematical model against the experimental runs.**
- A nonlinear dynamic inversion augmented with dual extended Kalman filter-based **robust control design** is proposed to account for process noises, measurement noise, and parameter inaccuracies.
- **Adaptive diffusion strategies in distributed information filter** for the fault tolerance control scheme is proposed to account for sensor failure and system degradation. Further, a Chi-square test based **event-triggered mechanism** is aligned with the closed-loop control design to identify the measurement failures.
- Developed **reinforcement learning-based model-free controller** to improve the tracking response of shaft speed signal and comparison is established by demonstrating the efficacy against well-known PID controller.
- **Digital twin of laboratory engine** is developed by utilizing the **time-series prediction capability of Deep Neural Network** and validated against experimental runs.

PUBLICATIONS/Google scholar

- "Dynamic modeling and robust nonlinear control of a laboratory gas turbine engine", Aerospace Science and Technology, Volume 126, 2022.
- "Reinforcement learning based control of a laboratory gas turbine engine", ready to be submitted in Part I: Journal of Systems and Control Engineering.
- "Active fault tolerant control of a gas turbine engine with modified covariance intersection approach", (Preprint ready).
- "Digital-twin of a laboratory gas turbine engine using deep learning framework", Chapter 6, Industry 4.0 in Small and Medium-Sized Enterprises (SMEs): Opportunities, Challenges, and Solutions, CRC Press, 2021.

- "Nonlinear control of a gas turbine engine with reinforcement learning", in *Future Technologies Conference - FTC*, Virtual / Vancouver, Canada, 2021.
- "Nonlinear control of a laboratory gas turbine engine with uncertain system dynamics", *International Symposium on Advances in Intelligent Robotics & Industrial Automation (IRIA'21)*, IIT Goa, India, 2021.
- "Nonlinear shaft speed control of laboratory gas turbine engine", *21st IFAC Symposium on Automatic Control in Aerospace*, vol. 52, no. 12, Cranfield, UK, pp. 262-267, 2019.
- "Modeling, simulation and validation of mini SR - 30 gas turbine engine", *3rd IFAC proceedings in Advances in Control and Optimization of Dynamical Systems*, vol. 51, no. 1, Hyderabad, India, pp. 554–559, 2018 (**Awarded as 3rd Best Paper**).

ACADEMIC PROJECTS

- **Master's Project**
  Steady-State & Dynamic Modelling, Simulation and Control of SR-30 Gas Turbine Engine.
  Guide: Prof. Arnab Maity, Co-guide: Prof. P. S. V. Nataraj [Jun 2017]
  - Developed a mathematical model for SR-30 gas turbine engine in MATLAB/Simulink environment and simulated it for steady-state and dynamic response.
  - Validated the simulated responses against experimental data from laboratory runs, particularly shaft speed of the engine.
  - Designed a PID controller to control the shaft speed response with fuel flow rate as control input.
- **Course projects**
  Cascade controller for robotic arm with end effector [Oct 2015]
  - Derived a transfer function with feedback controller and a pre-filter for the robotic arm.
  - Designed a proportional derivative controller for the robotic arm with end effecter as feedback & achieve required transient performance in MATLAB.

  Stage burn profile and nominal orbit information of INSAT 2-D [Apr 2016]
  - Generated ascent profile mission of Ariane 44L (3 stage rocket with booster) in MATLAB.
  - Solved for velocity, height and pitch angle attained & obtain the nominal trajectory assuming constant pitch rate using MATLAB.

  Designed controller and simulated the step response of a DC motor [Oct 2016]
  - Derived the system transfer function using step response and develop PID control algorithm.
  - Designed and implemented a QFT based PID controller to improve motor response.
  - Hands on experience with DC motor for simulation and compared various control strategy.

  State estimation of a CSTR tank with various filters [Oct 2017]
  - Kalman filter based state estimation of a CSTR tank in the presence of process and measurement noises.
  - A comparision is established by obtaining the state estimation using extended Kalman filter and unscented Kalman filter.

CURRICULUM HIGHLIGHTS

State Space Methods for Flight Vehicles, Control of Nonlinear Dynamical Systems, System Modelling, Dynamics and Control, Automation and Feedback Control, Ordinary Differential Equations, Optimization, State Estimation: Theory and Applications, Matrix Computations, Optimal Control Systems, Space Flight Dynamics, Aircraft Flight Dynamics, Introduction to Navigation and Guidance, Introduction to Flight, Aircraft Propulsion, Advanced Feedback Theory, Introduction to Flight.

RESEARCH WORK EXPERIENCE

- Teaching Assistantship for the courses
  - AE 699/427 Control system and laboratory (Spring 2016, 2018, 2019,2021)
  - AE 242 Measurement laboratory (spring 2017, 2020)
  - AE 308 Control Theory (Spring 2020)
  - AE 775 System Modelling, Dynamics and Control (Spring 2020)
  - AE 407 Modeling and simulation (Autumn 2019)
  - AE 792 Communication Skills (Autumn 2018)
- Contributions: Head practical session with hands-on tutorial in Python and MATLAB/Simulink
  - Continuing Education Program (CEP) Courses on Introduction to Machine Learning and Deep Learning with Application to Engineering Systems (9 times from Dec' 2018 to Oct' 2020)

  - TEQIP (Technical Education Quality Improvement Programme) workshop on Introduction to Deep Learning with Application to Engineering Systems", in Dec, 2020.
  - Pre-conference workshop on Application of Deep Learning in Engineering Application, TEQIP -III Sponsored international conference on Instrumentation and control engineering, NIT Trichy held at Dec 19, 2019.
- Guided 6 students in their short term projects so far in the field of application of machine learning and deep learning in engineering systems.

CONTRIBUTED TALKS

- **Matlab EXPO 2018** (Hyderabad, April 26, 2018), *Dynamic modeling of laboratory gas turbine engine using deep learning frameworks in Matlab*, International Convention Centre, Hyderabad - 500081, India.
- **Nvidia Developer Connect 2018** (Bengaluru, October 5, 2018), *Machine learning and deep learning applications in gas turbine engine*, Sheraton Grand, Hoodi, Whitefield, Bengaluru - 560048, India.
- **Maritime Research Center 2017** (Pune, October 26, 2017), *Neural network deployment for predicting dynamic behaviour of gas turbine engine*, Maritime Museum and Library, Deccan College Post Graduate and Research Institute, Pune, Maharashtra - 411006, India.

CONFERENCE & WORKSHOPS PARTICIPATIONS

- Future Technologies Conference FTC'2021,Vancouver, Canada, 28-29 October 2021, (Virtual).
- International Symposium on Advances in Intelligent Robotics & Industrial Automation, IIT Goa, India, 20-21 September 2021 (Virtual).
- 21st IFAC conference in Automatic Control in Aerospace, Cranfield, UK, August 2019.
- EDUMeet on Automation organized by IIT Bombay and Mitsubishi electric India pvt. Ltd on bridging the gap between industry and academia, 12th January 2019.
- 3rd IFAC conference in Automatic Control & Dynamic Optimization, Hyderabad, India, February 2018.
- TPL-NVDLI - Deep Learning institute organized by Nvidia on Image classification, segmentation and Neural network deployment using TensorRT, 24th, November 2017.

SOFTWARE SKILLS

- Languages: MATLAB/Simulink, Python (Basics in data handling and visualization, ML and DL Framework)
- Typography: Microsoft Word, Latex

MISCELLANEOUS

- Secured AIR 68 in GATE-2015 with 98.28 percentile.
- Reviewer of journal - Proceedings of the Institution of Mechanical Engineers, Part I: Journal of Systems and Control Engineering.
- Reviewer of conference - IEEE Conference on Control Technology and Applications (CCTA).
- Reviewer of conference - Advances in Control and Optimization of Dynamical Systems (ACODS).
- Volunteered teaching in ABHYASIKA to provide free education to resource constraints students (2017-19).
- Contributed as coordinator in Matlab/Simulink workshop organized in the institute.
- Awarded as Best Student Companion for the year 2016-17 for exemplary work and contribution.
- Gold and silver medal in badminton championship in IITB PG Sports (2015, 2016, 2022).
- Hobbies: Avid reader, Trek enthusiast, Mandala art beginner.
- Sports: Basketball, Badminton, Cycling, Running, Table tennis

References

- **Prof. Arnab Maity** (Supervisor)
  Associate Professor in Department of Aerospace Engineering, Indian Institute of Technology, Bombay
  https://www.aero.iitb.ac.in/home/people/faculty/arnab
  Mail: arnab@aero.iitb.ac.in | Contact: +91-022-2576 7136.
- **Prof. P. S. V. Nataraj** (Co-supervisor) Professor in Systems and Control Engineering, Indian Institute of Technology, Bombay
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- **Prof. Sharad Bhartiya** (Research supervisor)
  Professor in Department of Chemical Engineering, Indian Institute of Technology, Bombay
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