Fawad Farooq Ashraf

AEROSPACE ENGINEER · RESEARCH ASSOCIATE

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An Aerospace Engineer with interest in Flight Dynamics, Flight Vehicle Guidance - Navigation & Control, Nonlinear State Estimation & Filtering and Algorithm Design. A highly determined person in accepting the challenges positively and enhancing skills for personal development and commitment to the organization.

Education

IST (Institute of Space Technology)
Islamabad, Pakistan

BACHELOR OF SCIENCE IN AEROSPACE ENGINEERING
October 15, 2014 - August 01, 2018

- CGPA: 3.63/4.0 (90.75%), Cum Laude
- Thesis: Iterative Guidance Scheme for Satellite Launch Vehicles
- Projects:
  - Iterative Guidance Scheme for Satellite Launch Vehicles (Final Year Project): This project included the implementation and analysis of Saturn V guidance algorithm IGM (Iterative Guidance Mode) in a 3DOF GNC Simulation. The algorithm was compared with a reference solution developed using Pontryagin's minimum principle from the Optimal Control Theory.
  - Conceptual Design of a Liquid Propellant Rocket Engine as part of semester course 'Space Propulsion'.
  - Orbit Design & Analysis under Atmospheric Drag Perturbations as part of semester course 'Spacecraft Dynamics and Control'.
  - Aircraft Autopilot Designs using Proportional (P), Proportional-Derivative (PD) and Proportional-Integral-Derivative (PID) Controllers as part of semester course 'Flight Control Systems'.
  - Conceptual Design of a Supersonic Bomber Aircraft as part of semester course 'Aero-Vehicle Design'.
  - CAD Modeling of Aircraft using CATIA as part of semester course 'Computer Aided Designing'.
  - 3D Wing Meshing on ANSYS as part of semester course 'Computational Fluid Dynamics'.
  - Performance analysis of Boeing B-52 Stratofortress Aircraft as part of semester course 'Aero-Vehicle Performance'.
  - Design of a Supersonic Nozzle Inlet with Maximum Pressure Recovery as part of semester course 'Compressible Aerodynamics'.
  - Automatic Light Switching using Light Dependent Resistor as part of semester course 'Aerospace Instrumentation'.
  - Speed Control of a DC Motor using Potentiometer, H-Bridge and a Micro-Controller as part of semester course 'Circuits and Electronics'.

AIAA (American Institute of Aeronautics and Astronautics) - Continuing Education
Online

ONLINE CERTIFICATE COURSES

- Design of Space Launch Vehicles by Professor Don Edberg (April 11, 2022 – May 25, 2022; 30 classroom hours / 3.0 CEU)
- Flight Vehicle Guidance, Navigation and Control (GNC) - Analysis & Design by Professor Bong Wie (September 20, 2022 – October 13, 2022; 16 classroom hours / 1.6 CEU)

CUST (Capital University Of Science & Technology
Islamabad, Pakistan

CERTIFICATE COURSES

- Robust Control Systems (February 17, 2020 – June 19, 2020)
- Nonlinear Control Systems (March 08, 2021 – July 05, 2021)

IST (Institute of Space Technology)
Islamabad, Pakistan

WORKSHOPS

- Kalman Filtering - Design & Practical Considerations (July 15, 2019 – July 17, 2019)
- ANSYS Meshing (October 15, 2019 – October 17, 2019)
- Robust Control Design in MATLAB (March 15, 2022 – March 17, 2022)

Coursera
Online

ONLINE CERTIFICATE COURSES

- Machine Learning (Stanford University; March 02, 2022)
- Specialization: MATLAB Programming for Engineers & Scientists (Vanderbilt University)
  - Introduction to Programming with MATLAB (August 19, 2022)
  - Mastering Programming with MATLAB (October 06, 2022)
  - Introduction to Data, Signal & Image Analysis with MATLAB (October 20, 2022)

IEEE (Institute of Electrical and Electronics Engineers) XPLORE Continuing Education
Online

ONLINE CERTIFICATE COURSES

- What is the Internet of Things? (02/05/2020; 0.3 CEU)
- Intelligent Control of Connected and Automated Vehicles (May 09, 2020; 0.3 CEU)
- 3G, 4G and 5G Fundamentals (May 09, 2020 – May 10, 2020; 0.9 CEU)
- Radar Systems Engineering (May 13, 2020 – May 17, 2020; 5.4 CEU)

MathWorks Training Services

MathWorks Training Services *Online*

Online Training Certificates

- MATLAB Onramp (July 23, 2022)
- SIMULINK Onramp (July 29, 2022)
- Control Design Onramp with SIMULINK (September 24, 2022)

All Russian Space Festival *Online*

Online Certificate Course *April 12, 2020 - April 17, 2020*

- Introduction to Rocket and Satellite Engineering

Work Experience

Institute of Space Technology *Islamabad, Pakistan*

Research Associate *August 2018 - ongoing*

- Projects (Controls):
  - Robust, Optimal & Classical Control of an Inverted Pendulum on a Cart: Implemented $\mathcal{H}_\infty$ Loop Shaping, $\mathcal{H}_\infty$ Mixed Sensitivity, LQR & PID Controllers using MATLAB
  - Robust & Optimal Control of a Canard Configured Fighter Aircraft: Implemented $\mathcal{H}_\infty$ Loop Shaping, $\mathcal{H}_\infty$ Mixed Sensitivity, LQR, LQG & PID Controllers using MATLAB
  - Implementation of Exact Linearization Control of a Quadrotor via Dynamic Feedback: Implemented it as a benchmark example for Sensor-Fusion with Extended Kalman Filter and Nonlinear Set-Valued State Estimation & Fault Detection (Implemented using MATLAB & SIMULINK)
  - Implementation of LMI-based Full-State Feedback Linear, LPV & Piecewise Affine $\mathcal{H}_\infty$ Controllers: Tested on Inverted Pendulum with a Stationary Pivot Point & Inverted Pendulum on a Cart (Implemented using MATLAB & YALMIP)
  - Lipschitz Continuous Piecewise Affine Bounds of Nonlinear Systems (Based on Mesh-based Affine Abstraction Method): Applied on various Nonlinear Examples (Implemented using MATLAB & YALMIP)
  - Invariant & Reachability Set Computations (Based on Correct-by-Construction PCIS Approaches): Applied on Adaptive Cruise Control model for the design of MPC Controller (Implemented using MATLAB & MPT3)
- Projects (Guidance):
  - Implementation of Iterative Guidance Mode algorithm for SLVs: Implemented in 2D & 3D Reference Coordinate Frames with extension to Multi-Stages. Improved the algorithm for Long Coasting Arcs (Implemented in MATLAB)
  - Implementation of Optimal Guidance algorithm for SLVs (Based on Indirect Methods from Optimal Control Theory): Both 2D & 3D with Multi-Stage extension using MATLAB. Developed as a benchmark reference to compare other SLV guidance algorithms
  - Implementation of Space Shuttle Guidance algorithm (PEG & UPFG): Implemented in 2D Reference Frame using MATLAB. Working on 3D implementation and multistage extension
  - Implementation of Lambert guidance, Kepler's propagator, Proportional Navigation, ZEM/ZEV, Delta & Q-guidance algorithms for flight vehicles using MATLAB
- Projects (Navigation):
  - Implementation of Strapdown Inertial Navigation: For a fixed wing UAV & a Quadrotor using MATLAB & SIMULINK
  - GNSS-INS Integration using Extended Kalman Filter & Constrained Kalman Filter based on Constrained Zonotopes (MATLAB, SIMULINK, MPT3 & CORA2020)
- Projects (Optimization):
  - Implementation of Legendre-Gauss-Lobatto Pseudospectral Transcriptions (Based on Direct Optimal Control Methods): Applied on various optimization problems using MATLAB & GPOPS-I
  - Implementation of Collocation Methods for Optimal Control problems using MATLAB
  - Optimal Weights selection for $\mathcal{H}_\infty$ Mixed Sensitivity using Particle Swarm Optimization
- Projects (State Estimation & Filtering):
  - Implementation of Kalman Filter, Extended Kalman Filter & Constrained Kalman Filter based on Polytopic Sets: Implemented using MATLAB, MPT3 & CORA2020
  - Linear & Nonlinear Set-Valued State Estimation using Direct (Polytopes, Polyhedrons) & Indirect (Zonotopes, Constrained Zonotopes, Zonotope Bundles) Polytopic Sets using MATLAB, MPT3 & CORA2020
  - Implementation of algorithms for conversion of Polytopes to Zonotope Bundles and vice versa using MATLAB & YALMIP
  - Implementation of Continuous & Discrete Interval Observers using MATLAB & YALMIP
- Projects (Fault Detection):
  - Implementation of Fault Detection scheme based on Set-Membership approach using Constrained Zonotopes (Linear & Nonlinear)
  - Implementation of Oscillatory Failure Case (OFC) detection scheme for Actuator Fault of an Aircraft (based on a Nonlinear Observer & IIR Filter)
  - OFC detection for Actuator Failure using Linear Predictive Coding (LPC) & Signal Spectrum Analysis: Implemented using MATLAB
- Projects (Miscellaneous):
  - Implementation of Numerical Integration Techniques with Adaptive Step-Size Features (Runge-Kutta Fehlberg, Runge-Kutta Dormand Prince and Bulirsch-Stoer with Richardson Extrapolation). Also Fixed-Step Methods such as Euler Method, Heun's Method (Modified Euler), Classical Fourth-Order Runge-Kutta
  - Implementation of Maximum Object Enclosing Rectangle Algorithm & Largest Inscribed Isothetic Rectangle Algorithm
  - Connect4 (a game) AI using Reinforcement Learning
  - SLV Trajectory Analysis and Animation using Systems Toolkit (STK)

Centers of Excellence in Science & Applied Technologies *Islamabad, Pakistan*

Internee *May 2018 - July 2018*

- Exposure to various technologies being used in the aviation sector

Publications

Iterative Guidance Scheme for Satellite Launch Vehicles *16th IBCAST*

- Presented at Conference Proceedings of 16th International Bhurban Conference on Applied Sciences and Technology *January 2019*
- DOI: 10.1109/IBCAST.2019.8667124

Iterative Guidance Scheme for a Satellite Launch Vehicle along a Three Dimensional Trajectory *19th IBCAST*

- Presented at Conference Proceedings of 19th International Bhurban Conference on Applied Sciences and Technology *August 2022*
- DOI: 10.1109/IBCAST54850.2022.9990247

Feasibility Analysis of Numerical Integration Techniques in Onboard Flight Control Computer for Impact Point Prediction *19th IBCAST*

- Presented at Conference Proceedings of 19th International Bhurban Conference on Applied Sciences and Technology *August 2022*
- DOI: 10.1109/IBCAST54850.2022.9990191

$\mathcal{H}_\infty$ **Control of Scalar Nonlinear Systems** *IFAC World Congress 2023*

- Submitted to the 22nd World Congress of the International Federation of Automatic Control

Detection of Oscillatory Failures in Hydraulic Actuators of Aircraft using Linear Predictive Coding and Signal Spectrum Analysis *IFAC World Congress 2023*

- Submitted to the 22nd World Congress of the International Federation of Automatic Control

Honors & Awards

2018	**Gold Medal,** 1st Position in 2nd Academic Year of BS Aerospace Engineering	*IST, Pakistan*
2018	**Certificate of Appreciation,** 2nd Position in 1st Academic Year of BS Aerospace Engineering	*IST, Pakistan*
2018	**Dean's List of Honors,** Cum Laude Distinction	*IST, Pakistan*
2014	**Shield of Appreciation,** 1st Position in FSc Pre-Engineering	*PCIT, Pakistan*
2012	**Shield of Appreciation,** 1st Position in Matric (Science Group)	*DPS&C, Pakistan*
	Merit Scholarship, throughout Academic Career	

Skills

Softwares	MATLAB, Mathematica, ANSYS, CATIA, SolidWorks, LabView, Systems Toolkit (STK), MS Office, RDS, DATCOM, GPOPS-II
Programming	MATLAB, c, c++, Python, LaTeX
Languages	Urdu, English, Punjabi

Extracurricular Activities

Sports	Cricket (Beginner), Badminton (Amateur)
E-Gaming	Counter Strike - Global Offensive (Matchmaking Rank: Gold Nova Master), Tekken 7, GTA-V
Miscellaneous	Participated in several debate, essay writing and quiz competitions

References

Dr. Jamshed Riaz (PhD Flight Mechanics) *Islamabad, Pakistan*

Adjunct Professor at Institute of Space Technology

- Email: jamshed54@hotmail.com
- Contact: +92 321 8545029

Dr. Farooq Haydar (PhD Aerospace Engineering) *United Kingdom*

Senior Modelling, Simulation and Control Engineer at Animal Dynamics

- Email: mfarooqhaydar@gmail.com
- Contact: +92 332 8369505