Rameez Wajid

Formal methods and safe autonomy for cyber-physical systems

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Research Profile

I develop formal methods for the safety of autonomous and cyber-physical systems, with a focus on provable guarantees for nonlinear, stochastic, and partially learned dynamics. My work combines control barrier and Lyapunov functions, sum-of-squares optimization, and verification of real-valued programs, and has been applied to safety controller synthesis for unknown stochastic systems and nonlinear hybrid systems.

Research Interests

Formal verification of cyber-physical systems; control barrier and Lyapunov functions; sum-of-squares optimization and Positivstellensatz-based reasoning; verification of real-valued and hybrid programs; safe learning and Gaussian process-based control; autonomous robotics, autonomous driving, and flight control.

Education

University of Colorado Boulder — Boulder, CO
Ph.D. in Computer Science — *Expected 2026*
M.S. in Computer Science — *2023*
Research Area: Safety Verification for Cyber-Physical Systems
Advisor: Prof. Sriram Sankaranarayanan

Air University (AU) — Islamabad, Pakistan
M.S. in Control Systems — *2014*
Thesis: Automatic Prediction of Perceptual Image Quality (in collaboration with NTNU)
Advisors: Prof. Atif Mansoor (AU), Prof. Marius Pedersen (NTNU)
GPA: 3.70 / 4.00

National University of Sciences and Technology (NUST) — Islamabad, Pakistan
B.E. in Avionics Engineering (Graduation with distinction) — *2007*
Project: Development of Software for Safe Operation of Co-located Radars
GPA: 3.61 / 4.00, Rank: 2 / 40

Academic Appointments & Research Experience

University of Colorado Boulder — Boulder, CO
Graduate Research / Teaching Assistant, Department of Computer Science — *2020–present*

- Research on formal synthesis of safety controllers for unknown and stochastic control systems using control barrier functions, control Lyapunov functions, and sum-of-squares optimization.
- NSF-funded project: *Formal Synthesis of Safety Controllers for Unknown Stochastic Control*

Systems using Gaussian Process Learning.

- Toyota Research Institute North America (TRINA), Autonomous Vehicles Safety Project: *Safety certificates and runtime monitoring for learning-enabled autonomous driving systems.*
- Teaching assistant for CSEN 3104 (Algorithms; S'22, F'22, S'23, Su'23, S'24) and CSEN 4622 (Machine Learning; F'23).

Oregon State University Corvallis, OR
Graduate Research Assistant, School of EECS *2018–2019*

- Developed deep learning models (Deep Adaptive Writing Network) for print quality assessment in collaboration with HP Inc. (industry-funded).
- Worked on human 3D pose estimation using generative adversarial networks.
- Supported teaching for CS 562 (Software Project Management) and CS 372 (Introduction to Computer Networks, eCampus).

National University of Sciences and Technology (NUST) Islamabad, Pakistan
Lecturer, Department of Avionics Engineering *2014–2017*

- Taught control and computing courses; contributed to lab development and outcome-based accreditation activities.

Publications

Conference Papers

- **R. Wajid** and S. Sankaranarayanan. *Successive Barrier Functions for Nonlinear Systems.* Hybrid Systems: Computation and Control (HSCC), 2025.
- **R. Wajid**, A. U. Awan, and M. Zamani. *Formal Synthesis of Safety Controllers for Unknown Stochastic Control Systems using Gaussian Process Learning.* Learning for Dynamics and Control (L4DC), PMLR, 2022, pp. 624–636.
- **R. Wajid** and A. Bin Mansoor. *Classifier Performance Evaluation for Offline Signature Verification using Local Binary Patterns.* 4th European Workshop on Visual Information Processing (EUVIP), IEEE, Paris, 2013.
- **R. Wajid**, A. Bin Mansoor, and M. Pedersen. *A Study of Human Perception Similarity for Image Quality Assessment.* Colour and Visual Computing Symposium (CVCS), IEEE, Gjovik, 2013, pp. 1–6.
- **R. Wajid**, A. Bin Mansoor, and M. Pedersen. *A Human Perception-Based Performance Evaluation of Image Quality Metrics.* International Symposium on Visual Computing (ISVC), Springer, Las Vegas, 2014.

Manuscripts in Preparation

- Working title: Repulsive barrier certificates for moving obstacles in nonlinear systems.
- Working title: Dynamic perception contracts for learned perception modules in CPS.
- Working title: SOS Certificate Repair via DSOS and Rational LP: From floating-point witnesses to exact, checkable proofs.

Grants, Funding & Major Projects

- **Toyota Research Institute North America (TRINA), Autonomous Vehicles Safety Project:** Safety certificates and runtime monitoring for learning-enabled autonomous driving systems (graduate research assistant).
- **NSF-funded project:** Formal synthesis of safety controllers for unknown stochastic control systems using Gaussian process learning (graduate research assistant).
- **Industry-funded project (HP Inc.):** Deep Adaptive Writing Network for HP print quality assessment (graduate research assistant).
- **Low-cost flight simulators:** Flight dynamics and control modeling for T-37 trainer and Mirage fighter aircraft; integrated avionics, visuals, and dynamics for pilot training and mission rehearsal.

Teaching Experience

University of Colorado Boulder

Graduate Teaching Assistant, Department of Computer Science *2020–present*

- CSEN 3104: Algorithms (S'22, F'22, S'23, Su'23, S'24) – led recitations, held office hours, and developed supplemental problem sets in graph algorithms, dynamic programming, and complexity.
- CSEN 4622: Machine Learning (F'23) – supported project-based instruction in supervised/unsupervised learning and basic deep learning with Python.

National University of Sciences and Technology (NUST)

Lecturer, Department of Avionics Engineering *2014–2017*

- Courses: Modern Control Systems, Intro to Programming, Digital Logic and Computer Design Fundamentals, Computer-Aided Instrumentation, DC Circuit Analysis.

Oregon State University

Graduate Research Assistant with Teaching Duties *2018–2019*

- Teaching support for CS 562 (Software Project Management) and CS 372 (Intro to Computer Networks, eCampus).

Awards & Honors

- Outstanding Teaching Assistant Award, University of Colorado Boulder 2024
- Best Mentor Award, University of Colorado Boulder 2022
- Early Career Professional Development Fellowship, University of Colorado Boulder 2020
- Best Faculty Award, NUST 2016
- Chief of Air Staff Commendation for Excellence in R&D, Pakistan Air Force 2012
- Full Scholarship for M.S. (Air University) 2012

- Dean's Distinction List, NUST 2007
- Full Scholarship for B.E. (NUST) 2003
- High Achiever A-Levels (5 As) 2002

Professional Service

- Reviewer, European Control Conference (ECC), Bucharest, Romania 2023
- Reviewer, 61st IEEE Conference on Decision and Control (CDC), Cancun, Mexico 2022
- Reviewer, 14th IBCAST Conference, Islamabad, Pakistan 2016
- Core Volunteer, CS PhD Open House, University of Colorado Boulder 2024, 2025
- Volunteer, CS PhD Orientation, University of Colorado Boulder 2024
- Volunteer, POPL (Symposium on Principles of Programming Languages), Denver 2025

Industry Experience

Pakistan Air Force Pakistan
Simulation Systems Developer *2008–2012*

- Developed flight simulation solutions and in-flight situational awareness systems for training and evaluation in the aviation sector.

Selected Research & Industrial Projects

Cyber-Physical Systems & Autonomous Driving

- Decentralized multi-agent intersection management using neuroevolution-based controllers.
- Estimation of Responsibility-Sensitive Safety (RSS) parameters from NGSIM traffic data.

Computer Vision, Image Quality, and Machine Learning

- Offline signature verification for forgery detection using texture descriptors and classifier evaluation.
- Mathematical modeling of perceptual image quality and development of a color image database for image quality assessment research.

Flight Simulation & Situational Awareness

- Low-cost flight simulators for T-37 (trainer) and Mirage (fighter) aircraft.
- In-flight situational awareness systems to support early emergency detection and handling.

Technical Skills

Programming & Languages: C++, Python, Julia, C#, MATLAB, PyTorch, R, LabVIEW, ROS

Visualization & UI: Presagis Creator, TerraVista, VAPS XT, Unity3D

Simulation & Robotics: X-Plane, FlightGear, OMPL, OpenSim

Selected Graduate Coursework

Advanced Robotics; Social Robotics; Deep Learning; Machine Learning; Artificial Intelligence; Nonlinear Systems; Flight Dynamics and Control; Linear Multivariable Feedback Control; Digital Signal Processing; Random Processes; Adaptive Filtering; Optimal Control; Autonomous Systems; Linear Programming; Theory of Computation; Computer-Aided Verification.