

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

Ph.D. in Computer Science

M.S. in Computer Science

Research Area: Safety Verification for Cyber-Physical Systems

Advisor: Prof. Sriram Sankaranarayanan

Boulder, CO

Expected 2026

2023

Air University (AU)

M.S. in Control Systems

Islamabad, Pakistan

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)

B.E. in Avionics Engineering (Graduation with distinction)

Islamabad, Pakistan

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

Graduate Research / Teaching Assistant, Department of Computer Science

Boulder, CO

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 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

Graduate Research Assistant, School of EECS

Corvallis, OR
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)

Lecturer, Department of Avionics Engineering

Islamabad, Pakistan
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.