Akshay Rajhans

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Education

- **Ph.D.**, Electrical and Computer Engineering
  Carnegie Mellon University, Pittsburgh, PA, U.S.A.
  Advisor: Bruce H. Krogh
  Thesis Committee: Ken Butts (Toyota), David Garlan, André Platzer
- **M.S.**, Electrical Engineering
  University of Pennsylvania, Philadelphia, PA, U.S.A.
  Advisor: George J. Pappas
- **B.E.**, Electronics and Telecommunication
  University of Pune, Pune, India.

Professional Experience

MathWorks, Natick, MA **July 2013–Present**

Helping accelerate the innovation ecosystem at MathWorks

- Founding member of the Advanced Research & Technology Office
- Establishes research and advanced technology collaborations between MathWorks Engineering teams worldwide and universities and research labs around the world
- Represents MathWorks in the research community on research publications, talks, and on advisory boards
- Organizes and chairs MathWorks Research Summits in Boston and Tokyo
- Member of the Patent Review Board

Bosch, Pittsburgh, PA **Aug 2009–Dec 2009**

- Research intern. *Co-inventor on U.S. and international patents*

Cummins, Pune, India **Aug 2003–Dec 2005**

- Research, development, and Industrial Business Unit (IBU) applications engineering in electronic control of diesel and natural gas engines for *mining*, *marine*, *defense*, *rail*, *compressors*, *rigs*, *pumps*, *automotive*, and *construction*

Carnegie Mellon University, Pittsburgh, PA **Jul 2008–May 2013**

- PhD Candidate. Collaborative research with Toyota and others

University of Pennsylvania, Philadelphia, PA **Jan 2006–Jun 2008**

- Full time: Research staff at GRASP Lab; Part time: teaching assistant, administrative assistant

Technical Community Service

Industry Advisory Committees and Boards

- **Industry Advisory Board**, MIT's Climate & Sustainability Consortium, 2021–.
  `https://impactclimate.mit.edu/people/dr-akshay-rajhans/`.
- **Advisory Committee**, Veni grant titled "CODEC: Correct-by-design Estimation and Control of partially observable stochastic systems", Principal Investigator: Prof. Sofie Haessaert. Dutch Research Council (NWO), Domain Applied and Engineering Sciences, 2021–.
- **Industry Challenge Technical Program Committee**, Real-Time Systems Symposium (RTSS) 2022.
- **Industry Advisory Committee on Autonomous Vehicles Curriculum**, Robotics Engineering Program at Worcester Polytechnic Institute, 2017–18.

- **Industry Vice Chair**, IFAC Conference on Analysis and Design of Hybrid Systems (ADHS), 2018.
- **Industry Advisory Board**, International Symposium on Circuits and Systems (ISCAS), 2018.
- **Global Professional Advisory Community**, Association for Computing Machinery (ACM), 2017.

Conference Program Committee (PC) Leadership

- **Artifact Evaluation Chair**: • Formal Modeling and Analysis of Timed Systems (FORMATS) 2022
- **PC Chair**: • MathWorks Research Summits, Boston edition: 2017–, Tokyo edition: 2016– • Fourth International Workshop on Monitoring and Testing of CPS (MT-CPS), 2019 • Spring Simulation Conference (SpringSim) 2020 and 2019: CPS Track • Winter Simulation Conference (WSC) 2017: CPS Track
- **Awards Chair**: • Hybrid Systems: Computation and Control (HSCC) 2018
- **Demo and Poster Chair**: • Hybrid Systems: Computation and Control (HSCC) 2017
- **PC Member**: • Annual Modeling and Simulation Conference (AnnSim) 2021– • Formal Methods (FM) 2021– • International Conference on Cyber-Physical Systems (ICCPS) 2020–, 2015 • Multi-Paradigm Modeling for Cyber-Physical Systems (MPM4CPS) 2020– • Hybrid Systems: Computation and Control (HSCC) 2016–19 • International Conference on Informatics in Control, Automation and Robotics (ICINCO) 2020, 2017–18 • Winter Simulation Conference (WSC) 2017– • Numerical Software Verification Workshop (NSV) 2018–19 • International Workshop on Formal Co-Simulation of Cyber-Physical Systems (CoSim-CPS) 2017– • Summer Simulation Multi-Conference (SummerSim) 2014– • Conference on Analysis and Design of Hybrid Systems (ADHS), 2015
- **Repeatability Evaluation Committee Member**: • Hybrid Systems: Computation and Control (HSCC) 2014

Editorial Duties

- **Associate Editor, Technology Conferences Editorial Board**, IEEE Control System Society, 2020–
- **Editorial Advisory Board** Member, "Resilience in Cyber-Physical Systems: From Risk Modelling to Threat Counteraction," F. Flammini (Ed.), Springer.
- **Reviewer** for various journals and conferences in addition to those as a **PC Member**.

Technical Committees

- IEEE Technical Committee on Homeland Security

Talks

Keynote-Style Talks

K2. "*Challenges and Opportunities in Design and Operation of Intelligent Cyber-Physical Systems*", 19th International Runtime Verification Conference (RV), Part of 3rd World Congress on Formal Methods, Porto, Portugal. October 2019. **Chairs:** Leonardo Mariani and Bernd Finkbeiner.

K1. "*Multi-Paradigm Modeling for Design and Operation of Intelligent Cyber-Physical Systems*", First International Workshop on Multi-Paradigm Modeling for Cyber-Physical Systems (MPM4CPS), co-located with the MODELS Conference, Munich, Germany. September 2019. **Chairs:** Simon Van Mierlo and Hans Vangheluwe.

Invited Talks

T17. "*Formal Methods for Real-World Cyber-Physical Systems: A Model-Based Design Perspective*", Invited Talk, Brown University, Providence, RI. May 2022. **Hosts:** Profs. Tim Nelson and Shriram Krishnamurthi.

T16. "*Engineering Learning-Enabled Cyber-Physical Systems: Challenges and Opportunities*", Workshop on Machine Learning in Control (LEAC), part of Cyber-Physical Systems and Internet of Things (CPS-IoT) Week, remotely in Nashville, TN. May 2021. **Hosts:** Rafal Wisniewski and Manuela-Luminita Bujorianu, Workshop Chairs.

T15. "*Formal Methods for Real-World Cyber-Physical Systems: A personal perspective*", Invited Guest Lecture, Brown University course on Logic for Systems (CS 171), remotely in Providence, RI. March 2021. **Hosts:** Profs. Tim Nelson and Shriram Krishnamurthi.

T14. "Cyber-Physical Systems", Independent Activities Period (IAP), Massachusetts Institute of Technology, remotely in Cambridge, MA. January 2021.

T13. "*A Model-Based Design Perspective on Challenges and Opportunities in Automated Software Certification*", 20th Software Certification Consortium (SCC) Steering Committee Meeting, Annapolis, MD. May 2019. **Hosts:** Alan Wassyng and Mark Lawford, Organizers.

T12. "*Specification Formalisms for Cyber-Physical Systems: A Tools Perspective*", Dagstuhl Workshop on Specification Formalisms for Modern Cyber-Physical Systems, Dagstuhl, Germany. February 2019. **Hosts:** Jyotirmoy Deshmukh, Oded Maler, Dejan Nickovic, Workshop Organizers.

T11. "*Graphical Modeling of Hybrid Systems with Simulink and Stateflow*", Workshop honoring the retirement of Prof. Bruce Krogh, Carnegie Mellon University, Pittsburgh, PA. May 2018. **Host:** Bruno Sinopoli, Workshop Chair.

T10. "*A Vision for Application-Focused International Collaboration Networks in Cyber-Physical Systems*", NSF Visioning Workshop on International Networks for Advancing CPS Research, Development, and Education Worldwide, part of CPS Week 2018, Porto, Portugal. April 2018. **Hosts**: Seta Bogosyan, Frankie King, Ralph Wachter, National Science Foundation (NSF).

T9. "*Heterogeneous Model-Based Design of Tomorrow's Cyber-Physical Systems*", ECE Department Colloquia, Tufts University, Medford, MA. November 2017. **Host**: Prof. Usman Khan.

T8. "*Model-Based Design of Next Generation Cyber-Physical Systems*", MIT Workshop on Rethinking Modeling, Simulations and Control for the Changing Electric Energy Industry, Massachusetts Institute of Technology, Cambridge, MA, September 2017. **Hosts**: Prof. Marija Ilić and Prof. Ekaterina Kostina.

T7. "*Challenges and Opportunities for Intelligent Transportation Systems*", Robotica 2017, Newton, MA, June 2017. **Host**: Dr. Waseem Naqvi, AUVSI New England Chapter President, Chair.

T6. "*Model-Based Design of Connected Autonomous Vehicles*", 2nd IEEE Summer School on Connected and Autonomous Vehicles, Worcester Polytechnic Institute, Worcester, MA, May 2017. **Hosts**: Prof. Alexander Wyglinski and Prof. Raghvendra Cowlagi, Program Chairs.

T5. "*Model-Based Design Challenges for Cyber-Physical Systems*", Expeditions in Computer Augmented Program Engineering (ExCAPE) Principal Investigators' (PI) Meeting, University of Pennsylvania, Philadelphia, PA, May 2017. **Host**: Prof. Rajeev Alur, Principal Investigator.

T4. "*Safety in Freely-Composed Cyber-Physical Systems—Challenges and Opportunities*", with Pieter Mosterman, Exploring the Dimensions of Trustworthiness: Challenges and Opportunities Workshop, National Institute of Standards and Technology (NIST), Gaithersburg, MD, August, 2016. **Host**: Dr. Edward Griffor, Program Chair.

T3. "*Recent Advancements in MathWorks Verification and Validation Tools and Techniques*", CPS V&V I&F Workshop 2016, May 2016, Carnegie Mellon University. **Host**: Prof. André Platzer.

T2. "*Verification of Systems Using Robust Temporal Logic Testing*", Specification and Verification Center, School of Computer Science, Carnegie Mellon University, September 2008. **Host**: Prof. Edmund M. Clarke.

T1. "*Robustness of Temporal Logic Specifications for Testing of Signals*", Specification and Verification Center, School of Computer Science, Carnegie Mellon University, August 2008. **Host**: Prof. Edmund M. Clarke.

Panels

P7. "*Challenges in Satisfying the Need and Promotion of Modeling & Simulation Workforce*", Winter Simulation Conference, in hybrid mode at Phoenix, AZ, December 2021.

P6. "*Control for Climate Change Mitigation and Adaptation*", IEEE CSS Workshop on Control for Societal Challenges, online. June 2021.

P5. "*Future Challenges for Autonomous & Intelligent Transportation*", IEEE Situational Awareness for Emerging Transportation Systems (SAFENETS) Workshop, Lowell, MA, October 2019.

P4. "*Hybrid simulation for cyber-physical systems—where are we, and where do we want to go?*", Spring Simulation Conference (SpringSim), Baltimore, MD, April 2018.

P3. "*What are the Challenges Posed to CPS Theory by Modern Applications?*", Joint Panel between the Hybrid Systems: Computation and Control Conference (HSCC) and the International Conference on Cyber-Physical Systems (ICCPS), part of CPS Week, Porto, Portugal, April 2018.

P2. "*Why do we Need Holistic Concern-Driven Engineering?*", CPS Framework Open Source Workshop, National Institute for Standards and Technology (NIST), Rockville, MD, September 2017.

P1. "*Safety of Connected Autonomous Vehicles*", First International Workshop on the Safety of Connected Autonomous Vehicles (SCAV), part of CPS Week, Pittsburgh, PA, May 2017.

Publications and Patents

Theses

Th2. **Akshay Rajhans**, "*Multi-Model Heterogeneous Verification of Cyber-Physical Systems*", Ph.D. Thesis, Department of Electrical and Computer Engineering, Carnegie Mellon University, 2013. **Advisor:** Prof. Bruce H. Krogh.

Th1. **Akshay Rajhans**, "*Development of a Robust Testing Toolbox for Hybrid Systems*", M.S. Thesis, Department of Electrical and Systems Engineering, University of Pennsylvania, 2007. **Advisor:** Prof. George J. Pappas.

Patents

PP1. Burton Andrews, Diego Benitez, Badri Raghunathan and **Akshay Rajhans**, "*Method for Non-Intrusive Load Monitoring using a Hybrid System State Estimation Approach*", U.S., European, and International Patent, 2012.

Journal Papers

J5. Manuel Rodriguez, Xiangxue Zhao, Hayley Song, Anastasia Mavrommati, Roberto G. Valenti, **Akshay Rajhans**, Pieter J. Mosterman, Yancy Diaz-Mercado, and Hosam Fathy, "*A Gradient-Based Approach for Coordinating Smart Vehicles and Traffic Lights at Intersections*", IEEE Control Systems Letters (L-CSS), Volume: 5, Issue: 6.

J4. Frank Allgöwer, João Borges de Sousa, James Kapinski, Pieter Mosterman, Jens Oehlerking, Patrick Panciatici, Maria Prandini, **Akshay Rajhans**, Paulo Tabuada, Philipp Wenzelburger, "*Position Paper on the Challenges Posed by Modern Applications to Cyber-Physical Systems Theory*", Nonlinear Analysis: Hybrid Systems, Volume 34, Pages 147-165.

J3. **Akshay Rajhans**, Ajinkya Bhave, Ivan Ruchkin, Bruce H. Krogh, David Garlan, André Platzer and Bradley Schmerl, "*Supporting Heterogeneity in Cyber-Physical System Architectures*", IEEE Transactions on Automatic Control, Special issue on Cyber-Physical Systems, Volume 59, Issue 12, Pages 3178-3193.

J2. Matthias Althoff, **Akshay Rajhans**, Bruce H. Krogh, Soner Yaldiz, Xin Li and Larry Pileggi, "*Formal Verification of Phase-Locked Loops Using Reachability Analysis and Continuization*", Communications of the ACM, Volume 56, Issue 10, Pages 97-104. ***Research Highlight***.

J1. **Akshay Rajhans**, Shang-Wen Cheng, Bradley Schmerl, David Garlan, Bruce H. Krogh, Clarence Agbi, and Ajinkya Bhave, "*An Architectural Approach to the Design and Analysis of Cyber-Physical Systems*", Electronic Communications of the EASST, Volume 21, 2009.

Book Chapters

B2. Pieter J. Mosterman, **Akshay Rajhans**, Anastasia Mavrommati, Roberto G. Valenti, "*Simulation of Hybrid Dynamic Systems*", in John Baillieul, Tariq Samad, editors, Encyclopedia of Systems and Control, Springer, Living Edition. First online: August 2020.

B1. Sebastian Castro, Pieter J. Mosterman, **Akshay Rajhans**, and Roberto G. Valenti, "*Challenges in the Operation and Design of Intelligent Cyber-Physical Systems*", in Saurabh Mittal and Andreas Tolk, editors, Complexity Challenges in Cyber Physical Systems: Using Modeling and Simulation (M&S) to Support Intelligence, Wiley, January 2020.

Peer Reviewed Conference and Workshop Papers

C21. Mattia Di Florio, Vijay Iyer, **Akshay Rajhans**, Stefano Buccelli, Michela Chiappalone, "*Model-based Online Implementation of Spike Detection Algorithms for Neuroengineering Applications*", 44th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS) 2022 . Accepted.

C20. **Akshay Rajhans**, Anastasia Mavrommati, Pieter J. Mosterman, and Roberto G. Valenti, "*Specification and Runtime Verification of Temporal Assessments in Simulink*", 21st International Conference on Runtime Verification (RV) 2021.

C19. Anastasia Mavrommati, Carlos Osario, Roberto G. Valenti, **Akshay Rajhans**, and Pieter J. Mosterman, "*An Application of Model Predictive Control to Reactive Motion Planning of Robot Manipulators*", 17th IEEE International Conference on Automation Science and Engineering (CASE) 2021.

C18. Manuel Rodriguez, Xiangxue Zhao, Hayley Song, Anastasia Mavrommati, Roberto G. Valenti, **Akshay Rajhans**, Pieter J. Mosterman, Yancy Diaz-Mercado, and Hosam Fathy, "*A Gradient-Based Approach for Coordinating Smart Vehicles and Traffic Lights at Intersections*", American Control Conference (ACC) 2021.

C17. Nikita Visnevski, Teresa Hubscher-Younger, **Akshay Rajhans**, and Baoluo Meng, "*Automatic Synthesis of Information Flow Driven Execution Managers for Embedded Software Applications*", AIAA/IEEE Digital Avionics Systems Conference (DASC) 2020. ***Best in Session Award***.

C16. Zhan Tu, Anastasios Dimas, Mehmet N. Kurt, Anastasia Mavrommati, Pieter J. Mosterman, **Akshay Rajhans**, and Roberto G. Valenti, "*A Simulator for Trading Traffic Privileges by Selfish Driving Cars*", Spring Simulation Conference (SpringSim) 2020.

C15. Jean-Francois Kempf, Khoo Yit Phang, and **Akshay Rajhans**, "*Specification and Assessment of Temporal Requirements using Simulink Test*", Fourth International Workshop on Monitoring and Testing of Cyber-Physical Systems (MT-CPS 2019), part of CPS-IoT Week 2019.

C14. Akshay Rajhans and Dan Lluch, "A Digital Twin Approach to Online Monitoring in Industrial Internet of Things Applications", Fourth International Workshop on Monitoring and Testing of Cyber-Physical Systems (MT-CPS 2019), part of CPS-IoT Week 2019.

C13. Andreas Tolk, Fernando Barros, Andrea D'Ambrogio, **Akshay Rajhans**, Pieter J. Mosterman, Sachin S. Shetty, Mamadou K. Traoré, Hans Vangheluwe, and Levent Yilmaz, "*Hybrid Simulation for Cyber-Physical Systems—A Panel on Where we are Going Regarding Complexity, Intelligence, and Adaptability of CPS Using Simulation*", Spring Simulation Multi-Conference (SpringSim) 2018.

C12. **Akshay Rajhans**, Srinath Avadhanula, Alongkrit Chutinan, Pieter J. Mosterman, and Fu Zhang, "*Graphical Hybrid Automata with Simulink and Stateflow*", 21st ACM International Conference on Hybrid Systems: Computation and Control (HSCC) 2018.

C11. **Akshay Rajhans**, Srinath Avadhanula, Alongkrit Chutinan, Pieter J. Mosterman, and Fu Zhang, "*Graphical Modeling of Hybrid Dynamics with Simulink and Stateflow*", 21st ACM International Conference on Hybrid Systems: Computation and Control (HSCC) 2018. ***Best Repeatability Evaluation Award Finalist***.

C10. **Akshay Rajhans** and Pieter J. Mosterman, "*A Vision for Application-Focused International Collaboration Networks in Cyber-Physical Systems*", NSF Visioning Workshop for International Collaborations for Advancing CPS Research, Development, and Education Worldwide, part of CPS Week 2018.

C9. Yi Deng, **Akshay Rajhans**, and A. Agung Julius, "*STRONG: A Trajectory-Based Verification Toolbox for Hybrid Systems*", 10th International Conference on Quantitative Evaluation of SysTems (QEST) 2013.

C8. **Akshay Rajhans** and Bruce H. Krogh, "*Compositional Heterogeneous Abstraction*", 16th ACM International Conference on Hybrid Systems: Computation and Control (HSCC) 2013.

C7. **Akshay Rajhans** and Bruce H. Krogh, "*Heterogeneous Verification of Cyber-Physical Systems Using Behavior Relations*", 15th ACM International Conference on Hybrid Systems: Computation and Control (HSCC) 2012.

C6. **Akshay Rajhans**, Ajinkya Bhave, Sarah Loos, Bruce H. Krogh, André Platzer, and David Garlan, "*Using Parameters in Architectural Views to Support Heterogeneous Design and Verification*", IEEE Conference on Decision and Control (CDC) 2011.

C5. Matthias Althoff, **Akshay Rajhans**, Bruce H. Krogh, Soner Yaldiz, Xin Li, and Larry Pileggi, "*Formal Verification of Phase-Locked Loops Using Reachability Analysis and Continuization*", IEEE/ACM International Conference on Computer-Aided Design (ICCAD) 2011. ***William J. McCalla Best Paper Award***.

C4. Matthias Althoff, **Akshay Rajhans**, Bruce H. Krogh, Soner Yaldiz, Xin Li, and Larry Pileggi, "*Using Continuization in Reachability Analysis for the Verification of a Phase-Locked Loop*", Frontiers in Analog Circuit (FAC) Synthesis and Verification, co-located with Computer-Aided Verification (CAV) 2011.

C3. Ajinkya Bhave, David Garlan, Bruce H. Krogh, Sarah Loos, André Platzer, **Akshay Rajhans**, and Bradley Schmerl, "*Multi-View Consistency in Architectures for Cyber-Physical Systems*", Safe and Secure Systems & Software Symposium (S5) 2011.

C2. Ajinkya Bhave, David Garlan, Bruce H. Krogh, **Akshay Rajhans**, and Bradley Schmerl, "*Augmenting Software Architectures with Physical Components*", Embedded Real Time Software and Systems Conference (ERTS^2) 2010.

C1. Alexandre Donzé, Bruce H. Krogh, and **Akshay Rajhans**, "*Parameter Synthesis for Hybrid Systems with an Application to Simulink Models*", 12th International Conference on Hybrid Systems: Computation and Control (HSCC) 2009.

Student Mentoring and Teaching Assistantships

Ph.D. Thesis Committee

- Yi Deng, ECSE Department at Rensselaer Polytechnic Institute. **Advisor**: Prof. A. Agung Julius. **Thesis Title**: "*The Application of Trajectory-Based Analysis for Hybrid Systems*". Defended July 2015.

Student Competitions

- **MathWorks Technical Lead**, *CAT Vehicle Challenge*, online qualification rounds in a simulation environment and a final in-person round at the University of Arizona. **Instructor**: Prof. Jonathan Sprinkle, 2017.
- **Judge**, *CPS V&V Grand Prix*, 15-424/15-624/15-824: Foundations of Cyber-Physical Systems, Carnegie Mellon University. **Instructor**: Prof. André Platzer, 2017, 2016.

Teaching Assistantships

- **18-474: Embedded Control Systems**, ECE Department, Carnegie Mellon University, Spring 2011, Spring 2010.
- **MATH 114: Calculus II**, Mathematics Department, University of Pennsylvania, Spring 2008, Fall 2007.

- **ESE 210: Introduction to Dynamic Systems**, ESE Department, University of Pennsylvania, Spring 2007.
- **ESE 301: Introduction to Probability**, ESE Department, University of Pennsylvania, Fall 2006.

STEM Outreach

- (2021) **Panelist**, *New England Innovation Day*, New England FIRST Robotics (NE First). **Topic:** *STEM@Work*.
- (2009) **Laboratory Instructor**, *Summer Engineering Experience for Girls (SEE)*, a day-long summer camp for high-school students at Carnegie Mellon University. **Primary Instructor**: Prof. Bruno Sinopoli.
- (2002) **Instructor**, *Social Educational Activity*, organized by the IEEE Bombay Section Region 10 to create awareness amongst high-school students. **Topic:** *Mobile Communications*.

Software Skills

Developer: Simulink, Stateflow, SimEvents (at MathWorks), STRONG (at University of Pennsylvania)

User: Formal methods tools SpaceEx, PHAVer, Breach, KeYmaera (at Carnegie Mellon University)

Languages: MATLAB and C++ (professional), C and Java (graduate coursework), Python (beginner).

Professional Society Memberships

- Senior Member, Association for Computing Machinery (ACM), 2019—
- Senior Member, Institute of Electrical and Electronics Engineers (IEEE), 2019—