YU WANG

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EDUCATION

Ph.D. in Mechanical Engineering 2018
University of Illinois at Urbana-Champaign
Dissertation: Statistical verification and differential privacy in cyber-physical systems
Committee: Geir E. Dullerud (Advisor), Sayan Mitra, Mahesh Viswanathan, Matthew West, and Magnus Egerstedt

M.S. in Statistics 2017
University of Illinois at Urbana-Champaign

M.S. in Mathematics 2016
University of Illinois at Urbana-Champaign

M.S. in Mechanical Engineering 2014
University of Illinois at Urbana-Champaign
Dissertation: Stability of linear autonomous systems under regular switching sequences
Advisor: Geir E. Dullerud

B.E. in Engineering Mechanics 2012
Tsinghua University
Dissertation: A study of dynamic contact angles of shear-thickening power-law fluids
Advisor: Ke-Qin Zhu

RESEARCH INTERESTS

Cyber-Physical Systems ◇ Autonomy ◇ Robotics ◇ Machine Learning ◇ Formal methods ◇ Security and Privacy

RESEARCH EXPERIENCE

Postdoctoral Associate 2018 - now
Electrical and Computer Engineering, Duke University
Advisor: Miroslav Pajic

- Developed logical foundation for probabilistic hyperproperties. Proposed design and verification methods that addressed various security and privacy challenges for cyber-physical systems and robotics.
- Proposed machine learning methods for temporal logic objectives in robotic planning and statistical model checking.
- Proposed logic-based methods to design attack-resilient supervisors for smart infrastructures modeled by discrete event systems.
- Developed logic-based situation-awareness protocols for human/cyber-physical system interaction.

These works are supported by the National Science Foundation, Office of Naval Research, and Air Force Office of Scientific Research.

Graduate Research Assistant 2012 - 2018
Coordinated Science Laboratory, University of Illinois at Urbana-Champaign
Advisor: Geir E. Dullerud

- Developed verification methods for large-scale and complex cyber-physical systems. Developed statistical model checker STMC. Verified Toyota powertrain system.
- Designed differentially private communication mechanisms for distributed control and optimization.
- Proposed logic-based methods for resilient path planning of unmanned aerial vehicles.
- Proposed several stability and robustness criteria for constrained switched systems.

These works are supported by the National Science Foundation, Air Force Office of Scientific Research, and National Security Agency.

Undergraduate Research Assistant 2009 - 2012
Aerospace Engineering, Tsinghua University
Advisor: Ke-qin Zhu

- Compared and validated three physical models for dynamic contact angles of non-Newtonian fluids.

HONOR AND AWARDS

Best Paper Finalist 2019
ACM SIGBED International Conference on Embedded Software (**EMSOFT**)

CSL PhD Thesis Award Nomination 2018
Coordinated Science Laboratory, University of Illinois at Urbana-Champaign

George B. Grim Fellowship 2012
Department of Mechanical Engineering, University of Illinois at Urbana-Champaign

TEACHING AND MENTORING EXPERIENCE

Ph.D. Student Mentor 2018 - now
Mentees: Alper Bozkurt, Mahmoud Elfar, Siddhartha Nalluri, Mojtaba Zarei, Amir Khazraei, and Qitong Gao
Duke University

Teaching Assistant Spring 2018
Convex Methods in Control (ME 561)
University of Illinois at Urbana-Champaign

Teaching Assistant Spring 2017
Estimation and Stochastic Control (ME 598)
University of Illinois at Urbana-Champaign

RESEARCH PROPOSALS

[R1] Collaborative Research: SHF: Medium: Foundations of Formal and Scalable Verification of Hyperproperties in Probabilistic Systems, submitted as **Senior Personnel** (with PI: Borzoo Bonakdarpour, Michigan State University and PI: Miroslav Pajic, Duke University), **under review**.

PREPRINTS

[P1] **Yu Wang**, Mojtaba Zarei, Borzoo Bonakdarpour, and Miroslav Pajic, "Probabilistic Conformance for Cyber-Physical Systems". https://arxiv.org/abs/2008.01135

[P2] **Yu Wang**, Hussein Sibai, Sayan Mitra, and Geir E. Dullerud, "Differential Privacy for Sequential Algorithms". https://arxiv.org/abs/2004.00275

[P3] **Yu Wang**, Alper Kamil Bozkurt, and Miroslav Pajic, "Attack-Resilient Supervisory Control of Discrete Event Systems". https://arxiv.org/abs/1904.03264

[P4] **Yu Wang**, Nima Roohi, Matthew West, Mahesh Viswanathan, and Geir E. Dullerud, "Verifying Stochastic Hybrid Systems with Temporal Logic Specifications via Mori-Zwanzig Model Reduction". https://arxiv.org/abs/2009.07649

[P5] **Yu Wang**, Qitong Gao, and Miroslav Pajic, "Deep Learning for Stable Monotone Dynamical Systems". https://arxiv.org/abs/2006.06417

JOURNAL PUBLICATIONS

[J1] **Yu Wang**, Mojtaba Zarei, Borzoo Bonakdarpour, and Miroslav Pajic, "Statistical Verification of Hyperproperties for Cyber-Physical Systems", ACM Transactions on Embedded Computing Systems (**TECS**), vol. 18, no. 5s, pp. 1-23, 2019. [Presented at EMSOFT '19, Best Paper Finalist]

[J2] **Yu Wang**, Nima Roohi, Matthew West, Mahesh Viswanathan, and Geir E. Dullerud, "Statistical Verification of PCTL Using Antithetic and Stratified Samples", Formal Methods in System Design (**FMSD**), vol. 54, no. 2, pp. 145-163, 2019.

[J3] **Yu Wang**, Xuan Bi, and Annie Qu, "A Logistic Factorization Model for Recommender Systems with Multinomial Responses", Journal of Computational and Graphical Statistics (**JCGS**), pp. 1-9, 2019.

[J4] **Yu Wang**, Nima Roohi, Matthew West, Mahesh Viswanathan, and Geir E. Dullerud, "Stability Analysis of Switched Linear Systems Defined by Regular Languages", IEEE Transactions on Automatic Control (**TAC**), vol. 26, no. 5, pp. 2568-2575, 2017.

[J5] **Yu Wang**, Zhenqi Huang, Sayan Mitra, and Geir E. Dullerud, "Differential Privacy in Linear Distributed Control Systems: Entropy Minimizing Mechanisms and Performance Tradeoffs", IEEE Transactions on Control of Network Systems (**TCNS**), vol. 4, no. 1, pp. 118-130, 2017.

[J6] **Yu Wang** and Ke-Qin Zhu, "A Study of Dynamic Contact Angles of Shear-Thickening Power-Law Fluids", Physics of Fluids (**PoF**), vol. 26, no. 5, p. 052103, 2014.

CONFERENCE PUBLICATIONS

[C1] **Yu Wang**, Siddhartha Nalluri, Borzoo Bonakdarpour, and Miroslav Pajic, "Statistical Model Checking for Hyperproperties", Computer Security Foundations Symposium (**CSF**), **accepted**, Dubrovnik, Croatia, June 2021.

[C2] **Yu Wang**, Nima Roohi, Matthew West, Mahesh Viswanathan, and Geir E. Dullerud, "Verifying PCTL Specifications on Markov Decision Processes via Reinforcement Learning", IEEE Conference on Decision and Control (**CDC**), **accepted**, Jeju Island, Republic of Korea, Dec. 2020.

[C3] Mahmoud Elfar, **Yu Wang** and Miroslav Pajic, "Context-Aware Temporal Logic for Probabilistic Systems", International Symposium on Automated Technology for Verification and Analysis (**ATVA**), **accepted**, Hanoi, Vietnam, Oct. 2020.

[C4] Nima Roohi, **Yu Wang**, Matthew West, Geir E. Dullerud, and Mahesh Viswanathan, "STMC: Statistical Model Checker with Stratified and Antithetic Sampling", International Conference on Computer-Aided Verification (**CAV**), pp. 448-460, Los Angeles, CA, July 2020. [Results Replicated]

[C5] **Yu Wang** and Miroslav Pajic, "Hyperproperties for Robotics: Motion Planning via HyperLTL", IEEE International Conference on Robotics and Automation (**ICRA**), pp. 8462-8468, Paris, France, May 2020.

[C6] Alper Kamil Bozkurt, **Yu Wang**, Michael Zavlanos, and Miroslav Pajic, "Control Synthesis from Linear Temporal Logic Specifications Using Model-Free Reinforcement Learning", IEEE International Conference on Robotics and Automation (**ICRA**), pp. 10349-10355, Paris, France, May 2020.

[C7] Kyo Kim, Siddhartha Nalluri, Ashish Kashinath, **Yu Wang**, Sibin Mohan, Miroslav Pajic, and Bo Li "Security Analysis Against Spoofing Attacks for Distributed UAVs", Workshop on Decentralized IoT Systems and Security (**DISS**), pp. 1-6, San Diego, CA, Apr. 2020.

[C8] Mojtaba Zarei, **Yu Wang**, and Miroslav Pajic, "Statistical Verification of Learning-Enabled Controlled Systems", ACM International Conference on Hybrid Systems: Computation and Control (**HSCC**), pp. 1-7, Sydney, Australia, Apr. 2020. [Results Replicated]

[C9] **Yu Wang** and Miroslav Pajic, "Attack-Resilient Supervisory Control with Intermittently Secure Communication", IEEE Conference on Decision and Control (**CDC**), pp. 2015-2020, Nice, France, Dec. 2019.

[C10] **Yu Wang** and Miroslav Pajic, "Supervisory Control of Discrete Event Systems in the Presence of Sensor and Actuator Attacks", IEEE Conference on Decision and Control (**CDC**), pp. 5350-5355, Nice, France, Dec. 2019.

[C11] **Yu Wang**, Mojtaba Zarei, Borzoo Bonakdarpour, and Miroslav Pajic, "Statistical Verification of Hyperproperties for Cyber-Physical Systems", ACM SIGBED International Conference on Embedded Software (**EMSOFT**), pp. 1-23, Oct. 2019. [Journal-Track, Best Paper Award Finalist]

[C12] Mahmoud Elfar, **Yu Wang** and Miroslav Pajic, "Security-Aware Synthesis Using Delayed-Action Games", International Conference on Computer-Aided Verification (**CAV**), pp. 180-199, New York, NY, July 2019.

[C13] **Yu Wang**, Nima Roohi, Matthew West, Mahesh Viswanathan, and Geir E. Dullerud, "Statistical Verification of PCTL Using Stratified Samples", IFAC Conference on Analysis and Design of Hybrid Systems (**ADHS**), IFAC-PapersOnLine, vol. 51, no. 1, pp. 85-90, Oxford, UK, July 2018.

[C14] **Yu Wang**, Sayan Mitra, and Geir E. Dullerud, "Differential Privacy and Minimum-Variance Unbiased Estimation in Multi-Agent Control Systems", IFAC World Congress (**WC**), IFAC-PapersOnLine, vol. 50, pp. 9521-9526, Toulouse, France, July 2017.

[C15] Nima Roohi, **Yu Wang**, Matthew West, Geir E. Dullerud, and Mahesh Viswanathan, "Statistical Verification of the Toyota Powertrain Control Verification Benchmark", ACM International Conference on Hybrid Systems: Computation and Control (**HSCC**), pp. 65-70, Pittsburgh, PA, Apr. 2017.

[C16] **Yu Wang**, Nima Roohi, Matthew West, Mahesh Viswanathan, and Geir E. Dullerud, "Verifying Continuous-Time Stochastic Hybrid Systems via Mori-Zwanzig Model Reduction", IEEE Conference on Decision and Control (**CDC**), pp. 3012-3017, Las Vegas, NV, Dec. 2016.

[C17] **Yu Wang**, Hale Hale Matthew, Magnus Egerstedt, and Geir E. Dullerud, "Differentially Private Objective Functions in Distributed Cloud-Based Optimization", IEEE Conference on Decision and Control (**CDC**), pp. 3688-3694, Las Vegas, NV, Dec. 2016.

[C18] Zhenqi Huang, **Yu Wang**, Sayan Mitra, and Geir E. Dullerud, "Controller Synthesis for Linear Dynamical Systems with Adversaries", ACM Symposium and Bootcamp on the Science of Security (**HoTSoS**), pp. 53-62, Pittsburgh, PA, Apr. 2016.

[C19] Zhenqi Huang, **Yu Wang**, Sayan Mitra, Geir E. Dullerud, and Swarat Chaudhuri, "Controller Synthesis with Inductive Proofs for Piecewise Linear Systems: An SMT-Based Algorithm", IEEE Conference on Decision and Control (**CDC**), pp. 7434-7439, Osaka, Japan, Dec. 2015.

[C20] **Yu Wang**, Nima Roohi, Matthew West, Mahesh Viswanathan, and Geir E. Dullerud, "A Mori-Zwanzig and MITL Based Approach to Statistical Verification of Continuous-Time Dynamical Systems", IFAC Conference on Analysis and Design of Hybrid Systems (**ADHS**), IFAC-PapersOnLine, vol. 48, no. 27, pp. 267-273, Atlanta, GA, Oct. 2015.

[C21] **Yu Wang**, Nima Roohi, Matthew West, Mahesh Viswanathan, and Geir E. Dullerud, "Statistical Verification of Dynamical Systems Using Set Oriented Methods", ACM International Conference on Hybrid Systems: Computation and Control (**HSCC**), pp. 169-178, Seattle, WA, Apr. 2015.

[C22] **Yu Wang**, Zhenqi Huang, Sayan Mitra, and Geir E. Dullerud, "Entropy-Minimizing Mechanism for Differential Privacy of Discrete-Time Linear Feedback Systems", IEEE Conference on Decision and Control (**CDC**), pp. 2130-2135, Los Angeles, CA, Dec. 2014.

[C23] **Yu Wang**, Nima Roohi, Geir E. Dullerud, and Mahesh Viswanathan, "Stability of Linear Autonomous Systems under Regular Switching Sequences", IEEE Conference on Decision and Control (**CDC**), pp. 5445-5450, Los Angeles, CA, Dec. 2014.

[C24] Zhenqi Huang, **Yu Wang**, Sayan Mitra, and Geir E. Dullerud, "On the Cost of Differential Privacy in Distributed Control Systems", International Conference on High Confidence Networked Systems (**HiCoNS**), pp. 105-114, Berlin, Germany, Apr. 2014.

SOFTWARE ARTIFACTS

[A1] STMC: Statistical model checker with stratified and antithetic sampling.

[A2] ARSC: Design toolbox for attack-resilient supervisory controllers.

[A3] HyperSMC: Statistical model checker for hyper probabilistic temporal logics.

[A4] MPHyper: Symbolic motion planner for HyperLTL objectives.

[A5] CSRL: Control synthesis for LTL objectives by reinforcement learning.

[A6] SMCLearning: Statistical model checker for deep-neural-network-enabled cyber-physical systems.

INVITED TALKS

[I1] "Verifying the Security of Cyber-Physical Systems", Postdoc Plenary Talk, Southeast Controls Conference, Atlanta, GA, Sept. 2019.

[I2] "Verifying the Security of Cyber-Physical Systems", Department of Computer Science, Iowa State University, Sept. 2019.

[I3] "Security and Privacy in Cyber-Physical Systems", Kevin T. Crofton Department of Aerospace and Ocean Engineering, Virginia Polytechnic Institute and State University, Feb. 2019.

[I4] "Statistical Verification and Differential Privacy in Cyber-Physical Systems", Department of Electrical and Computer Engineering, University of New Mexico, May 2018.

[I5] "Statistical Verification and Differential Privacy in Cyber-Physical Systems", GRASP Lab, Department of Electrical and Systems Engineering, University of Pennsylvania, Nov. 2017.

[I6] "Differential Privacy, Entropy and Security in Distributed Control of Cyber Physical Systems", TSS/SoS Seminar, Information Trust Institute, University of Illinois at Urbana-Champaign, Apr. 2016.

[I7] "A Mori-Zwanzig and MITL Based Approach to Statistical Verification of Continuous-time Dynamical Systems", Midwest Verification Day, Urbana, IL, Oct. 2015.

CONFERENCE PRESENTATIONS

[T1] "Statistical Verification of Hyperproperties for Cyber-Physical Systems", International Conference on Robotics and Automation (**ICRA**), Nice, France, June 2020. [Virtual]

[T2] "Statistical Verification of Learning-Based Cyber-Physical Systems", International Conference on Hybrid Systems: Computation and Control (**HSCC**), Sydney, Australia, Apr. 2020. [Virtual]

[T3] "Statistical Verification of Hyperproperties for Cyber-Physical Systems", International Conference on Embedded Software (**EMSOFT**), New York, NY, Oct. 2019.

[T4] "Differential Privacy and Minimum-Variance Unbiased Estimation in Multi-Agent Control Systems", IFAC World Congress (**WC**), Toulouse, France, July 2017.

[T5] "Verifying Continuous-Time Stochastic Hybrid Systems via Mori-Zwanzig Model Reduction", IEEE Conference on Decision and Control (**CDC**), Las Vegas, NV, Dec. 2016.

[T6] "Differentially Private Objective Functions in Distributed Cloud-Based Optimization", IEEE Conference on Decision and Control (**CDC**), Las Vegas, NV, Dec. 2016.

[T7] "Controller Synthesis for Linear Dynamical Systems with Adversaries", ACM Symposium and Bootcamp on the Science of Security (**HoTSoS**), Pittsburgh, PA, Apr. 2016.

[T8] "Statistical Verification of the Toyota Powertrain Control Verification Benchmark", ACM International Conference on Hybrid Systems: Computation and Control (**HSCC**), Vienna, Austria, Apr. 2016. [Poster]

[T9] "A Mori-Zwanzig and MITL Based Approach to Statistical Verification of Continuous-Time Dynamical Systems", IFAC Conference on Analysis and Design of Hybrid Systems (**ADHS**), Atlanta, GA, Oct. 2015.

[T10] "Statistical Verification of Dynamical Systems Using Set Oriented Methods", ACM International Conference on Hybrid Systems: Computation and Control (**HSCC**), Seattle, WA, Apr. 2015.

[T11] "Entropy-Minimizing Mechanism for Differential Privacy of Discrete-Time Linear Feedback Systems", International Conference on Embedded Software (**CDC**), Los Angeles, CA, Dec. 2014.

[T12] "Stability of Linear Autonomous Systems under Regular Switching Sequences", International Conference on Embedded Software (**CDC**), Los Angeles, CA, Dec. 2014.

ACADEMIC SERVICES

Reviewer for American Control Conference (**ACC**), European Control Conference (**ECC**), Conference on Decision and Control (**CDC**), International Conference on Hybrid Systems: Computation and Control (**HSCC**), International Conference on Cyber-Physical Systems (**ICCPS**), AAAI Conference on Artificial Intelligence (**AAAI**), International Symposium on Automated Technology for Verification and Analysis (**ATVA**), International Conference on integrated Formal Methods (**iFM**), Conference on Decision and Game Theory for Security (**GameSec**), IEEE Transactions on Automatic Control (**TAC**), IEEE Transactions on Control of Network Systems (**TCNS**), Control Systems Letters, (**L-CSS**) IEEE Transactions on Signal Processing, (**TSP**) IEEE Transactions on Intelligent Transportation Systems (**TITS**), **Neurocomputing**, and **Automatica**.