

# IVAN PAPUSHA, PHD

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## Experience

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<i>Senior Technical Advisor</i> · Washington, DC	2021–
<i>Senior Professional Staff</i> · Space Exploration Sector, Johns Hopkins Univ./APL, Laurel, MD	2018–2021
<i>Postdoctoral Fellow</i> · Oden Institute, University of Texas at Austin, TX	2016–2018
<i>Graduate Researcher</i> · Control and Dynamical Systems Department, Caltech, Pasadena, CA	2011–2016
<i>Research Analyst</i> · Prediction and Bidding Team, AOL Inc., Palo Alto, CA	2011
<i>Researcher</i> · Stanford AI Laboratory, Stanford University, Stanford, CA	2010
<i>Researcher</i> · Center for Integrated Systems, Stanford University, Stanford, CA	2009
<i>Engineering Technician</i> · Naval Research Laboratory, Washington, DC	2006, 2008

## Education

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<i>California Institute of Technology</i> · Pasadena, CA
◦ PhD, Computing and Mathematical Sciences, 2016 <i>Thesis</i> : Robustness, Adaptation, and Learning in Optimal Control <i>Advisor</i> : Richard M. Murray (Control and Dynamical Systems)
<i>Stanford University</i> · Stanford, CA
◦ MS, Electrical Engineering, 2011 ◦ BS, Electrical Engineering (physics minor), 2011
<i>Thomas Jefferson High School for Science and Technology</i> · Alexandria, VA
◦ Advanced Studies Diploma, 2007

## Tools and expertise

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*Software*\*: Python, C/C++, Rust, JavaScript, Cloud (AWS/Azure/etc.), DevSecOps, Docker, SQL, bash  
*Data Analysis*\*: numpy/scipy/pandas, pytorch/tensorflow, matlab  
*Statistics/Machine Learning*\*: convex optimization, regression, classification, neural networks, research  
*Control Systems*†: robust/adaptive/model predictive control, trajectory generation, hybrid systems  
*Formal Methods*†: model checking, theorem proving, compilers, SMT/Z3, Lean, Coq, AI/LLM agents  
*Mechanical Design*†: SolidWorks, Creo, Fusion 360, PCB design, 3D printing, mill/shop, robotics  
*Electrical Design*†: Verilog, ModelSim, Cadence, Eagle, SPICE, microcontrollers  
*Earth and Space*†: AGI Systems Tool Kit, NAIF SPICE, ArcGIS

\*core tools    †specialized tools

## Teaching

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<i>Instructor</i> · Caltech	2015
◦ CDS270–2: Mathematical Methods in Control and System Engineering, Spring 2015	
<i>Teaching Assistant</i> · Stanford, Caltech	2010–2014
◦ EE364A: Convex Optimization I, Winter 2011 (Stephen Boyd)	
◦ EE263: Linear Dynamical Systems, Fall 2010 (Stephen Boyd)	
◦ EE102B: Signal Processing and Linear Systems II, Spring 2011 (Joseph M. Kahn)	
◦ CDS101/110A: Introductory Control Theory, Fall 2013, Fall 2014 (Douglas MacMartin)	

## Awards and activities

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Packard Award for Excellence in Acquisition, 2019  
National Defense Science and Engineering Graduate Fellowship (NDSEG), 2012–2015  
Caltech Powell Foundation Fellowship, 2011  
AFCEA Scholarship, 2008–2010  
Professional: IEEE member  
Personal: STEM outreach, mentoring students, scuba, rock climbing

## Sample Software

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- LATERN-SMT: (“Safer than a torch”) Utility functions for encoding PyTorch modules as Z3 constraints.  
<https://github.com/JHUAPL/lantern-smt>
- AMNET: Python toolbox for formally verifying neural networks.  
<https://github.com/ipapusha/amnet>
- SYDAR: (Synthesis Done Approximately Right) approximate control synthesis for hybrid automata.  
<https://github.com/u-t-autonomous/sydar>
- BOXQP: primal-dual quadratic program solver for Matlab with explicit offline factorization analysis.  
<https://github.com/ipapusha/boxqp>
- PCPADMM: solver for the robust PCA problem via principal component pursuit.  
[http://ivanpapusha.com/code/pcp\\_admm.m](http://ivanpapusha.com/code/pcp_admm.m)

## Publications

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### Autonomy and Machine Learning

- [1] Y. Kouskoulas, T. J. Machado, D. Genin, A. Schmidt, I. Papusha, and J. Brulé. Envelopes and waves: Safe multivehicle collision avoidance for horizontal non-deterministic turns. *Software Tools for Technology Transfer*, 24:371–394, May 2022. DOI: 10.1007/s10009-022-00654-2.
- [2] D. Genin, I. Papusha, J. Brulé, T. Young, G. Mullins, Y. Kouskoulas, R. Wu, and A. Schmidt. Formal verification of neural network controllers for collision-free flight. In *Workshop on Numerical Software Verification (NSV), part of International Conference on Computer-Aided Verification (CAV)*. Jul. 2021. DOI: 10.1007/978-3-030-95561-8\_9.
- [3] Y. Kouskoulas, D. Genin, A. Schmidt, I. Papusha, R. Wu, G. Mullins, T. Young, and J. Brulé. Verification of safety in artificial intelligence and reinforcement learning systems. *Johns Hopkins APL Technical Digest*, 35(4):434–437, 2021.
- [4] I. Papusha, R. Wu, J. Brulé, Y. Kouskoulas, D. Genin, and A. Schmidt. Incorrect by construction: Fine tuning neural networks for guaranteed performance on finite sets of examples. In *3rd Workshop on Formal Methods in ML-Enabled Autonomous Systems (FoMLAS)*. Jul. 2020. arXiv:2008.01204 [cs.LG].
- [5] D. Genin, E. Dietrich, Y. Kouskoulas, A. Schmidt, M. Kobilarov, K. Katyal, S. Sefati, S. K. Mishra, and I. Papusha. A safety fallback controller for improved collision avoidance. In *IEEE International Conference on Assured Autonomy (ICAA)*. Jun. 2023. <https://icaa-conf.github.io/icaa2023/>.

### Air and Space Systems

- [6] M. A. Kelly, J. L. Carr, D. L. Wu, A. C. Goldberg, I. Papusha, and R. T. Meinhold. Compact Midwave Imaging System: Results from an airborne demonstration. *Remote Sensing*, 14(4), 2022. DOI: 10.3390/rs14040834.
- [7] M. A. Kelly, D. Wu, A. Goldberg, I. Papusha, J. Wilson, J. Carr, J. Boldt, J. Greenberg, F. Morgan, S. Yee, A. Heidinger, and L. Mehr. Compact Midwave Imaging System (CMIS) for retrieval of Cloud Motion Vectors (CMVs) and Cloud Geometric Heights (CGHs). In *Proceedings of the SPIE*, vol. 10776. Oct. 2018. DOI: 10.1117/12.2324612.
- [8] M. Cubuktepe, N. Jansen, S. Junges, J.-P. Katoen, I. Papusha, H. A. Poonawala, and U. Topcu. *Sequential Convex Programming for the Efficient Verification of Parametric MDPs*, pp. 133–150. Springer, Apr. 2017. DOI: 10.1007/978-3-662-54580-5\_8.
- [9] S. S. Farahani, I. Papusha, C. McGhan, and R. M. Murray. Constrained autonomous satellite docking via differential flatness and model predictive control. In *IEEE Conference on Decision and Control (CDC)*, pp. 3306–3311. Dec. 2016. DOI: 10.1109/CDC.2016.7798766.

### Control Theory and Convex Optimization

- [10] I. Papusha, U. Topcu, S. Carr, and N. Lauffer. Affine Multiplexing Networks: System analysis, learning, and computation, Apr. 2018. arXiv:1805.00164 [math.OC].
- [11] I. Papusha, M. Wen, and U. Topcu. Inverse optimal control with regular language specifications. In *American Control Conference (ACC)*, pp. 770–777. Jun. 2018. DOI: 10.23919/ACC.2018.8431646.

- [12] M. Wen, I. Papusha, and U. Topcu. Learning from demonstrations with high-level side information. In *International Joint Conference on Artificial Intelligence (IJCAI)*, pp. 3055–3061. Aug. 2017. DOI: 10.24963/ijcai.2017/426.
- [13] J. Fu, I. Papusha, and U. Topcu. Sampling-based approximate optimal control under temporal logic constraints. In *ACM International Conference on Hybrid Systems: Computation and Control (HSCC)*, pp. 227–235. Apr. 2017. DOI: 10.1145/3049797.3049820.
- [14] I. Papusha, J. Fu, U. Topcu, and R. M. Murray. Automata theory meets approximate dynamic programming: Optimal control with temporal logic constraints. In *IEEE Conference on Decision and Control (CDC)*, pp. 434–440. Dec. 2016. DOI: 10.1109/CDC.2016.7798307.
- [15] I. Papusha. *Robustness, Adaptation, and Learning in Optimal Control*. Ph.D. thesis, California Institute of Technology, May 2016. DOI: 10.7907/Z9F18WPB.
- [16] I. Papusha and R. M. Murray. Analysis of control systems on symmetric cones. In *IEEE Conference on Decision and Control (CDC)*, pp. 3971–3976. Dec. 2015. DOI: 10.1109/CDC.2015.7402836.
- [17] M. B. Horowitz, I. Papusha, and J. W. Burdick. Domain decomposition for stochastic optimal control. In *IEEE Conference on Decision and Control (CDC)*, pp. 1866–1873. Dec. 2014. DOI: 10.1109/CDC.2014.7039670.
- [18] I. Papusha, E. Lavretsky, and R. M. Murray. Collaborative system identification via parameter consensus. In *American Control Conference (ACC)*, pp. 13–19. Jun. 2014. DOI: 10.1109/ACC.2014.6858938.