Domagoj Tolić

CONTACT INFORMATION

Lecturer
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RESEARCH INTERESTS

Hybrid Systems, Networked Control Systems, Nonlinear Control, Multi-Agent Systems, Robotics, Approximate Dynamic Programming, Reinforcement Learning

EDUCATION

University of New Mexico, Albuquerque, NM, USA
Ph.D., Electrical Engineering (Control Systems) **August 2008 – August 2012**

- Advisor: Professor Rafael Fierro
- Thesis Title: Estimation and Stability of Nonlinear Control Systems under Intermittent Information with Applications to Multi-Agent Robotics
- GPA: 4.16/4.00

University of Zagreb, Zagreb, Croatia
B.S., Mathematics **September 2005 – July 2008**

- GPA: 4.53/5.00

University of Zagreb, Zagreb, Croatia
M.S., Electrical Engineering **September 2005 – September 2007**

- Major: Control Systems
- Advisor: Professor Stjepan Bogdan
- Research Topic: Event-Driven Systems Employing a Matrix-Based Formalism
- GPA: 4.66/5.00

University of Zagreb, Zagreb, Croatia
B.S., Electrical Engineering **September 2002 – July 2005**

AWARDS AND DISTINCTION

- Best paper award at the International Conference on Smart Systems and Technologies (SST) for the paper titled "Intermittent Information in Networked Control Systems" and co-authored with I. Palunko, October 2016
- Full scholarship for a PhD program at University of New Mexico, NM, USA, 2008 - 2012
- "Josip Lončar" award granted by the Faculty of Electrical Engineering and Computing, University of Zagreb, as the best student in Control Systems for the academic year 2004/05
- Scholarship from the Croatian Ministry of Science, Education and Sports in the category of particularly talented students in duration of 4 years starting in the academic year 2003/04

PROFESSIONAL EXPERIENCE

Rochester Institute of Technology, Dubrovnik, Croatia

Lecturer **March 2017 – present**

Adjunct Professor **September 2015 – March 2017**

Teaching the following IT courses: Computer Problem Solving for the Information Domain, Server Programming, Software Design Principles and Patterns, Foundations of Mobile Design, Foundations of Modern Information Processing, Web and Mobile.

University of Dubrovnik, Dubrovnik, Croatia

Postdoctoral Researcher **October 2015 – March 2017**

Within "EuRoC: European Robotics Challenge, Challenge 3", I focus on motion planning, surface inspection and reactive obstacle avoidance in 3D environments. Among 35 competing robotics teams, we finished up in the third place.

University of Melbourne, Melbourne, Australia

Honorary Fellow **November 2016**

Host: Professor Dragan Nešić, Deputy Head for Research & Industry Engagement of the Electrical and Electronic Engineering Department.

This part of my work focuses on control architectures that allow for greater delays in Networked Control Systems.

Technical University of Munich, Munich, Germany

Visiting Researcher **October 2013 – June 2014**

Host: Professor Sandra Hirche, Chair of Information-oriented Control

The part of my work developed during this period focuses on delays in Networked Control Systems.

University of Zagreb, Zagreb, Croatia

Postdoctoral Researcher **September 2012 – September 2015**

One part of my research, funded by the FP7 project ACROSS, extends and generalizes the ideas developed during my PhD program. As of October 2014, the other part of my research is to design an adaptive autism spectrum disorder diagnostic protocol within the Autism Diagnostic Observation with Robot Evaluator (ADORE) project.

University of New Mexico, Albuquerque, NM, USA

Research Assistant **August 2008 – August 2012**

My PhD is focused on stability and estimation under intermittent information for nonlinear control systems. Applications of the developed theory are in the area of multi-agent robotics. The utilized tools are : the small-gain theorem, Lp-stability, hybrid systems, switched systems, networked control systems, convex optimization, event-triggering, self-triggering, particle filtering, unscented Kalman filtering, geometric optimization, and algebraic graph theory.

Teaching Assistant

- **2009 - Spring**: ECE 446 - Design of Feedback Control Systems (Prof. Rafael Fierro)
- **2008 - Fall**: ECE 445 - Introduction to Control Systems (Prof. Rafael Fierro)

University of Zagreb, Zagreb, Croatia

Research Assistant **September 2005 – September 2007**

My master thesis investigates Free Choice Multiple Reentrant Flowlines (FMRF) employing a matrix-based formalism.

Publications

Journals

(J1) Buşoniu, L.; de Bruin, T.; **Tolić, D.**; Kober, J.; Palunko, I.; "Reinforcement Learning for Control: Performance, Stability, and Deep Approximators," Annual Reviews in Control, Vol.46, pp. 8-28, 2018.

(J2) **Tolić, D.**; Palunko, I.; "Robustness of Nonlinear Control Systems to Network-Induced Imperfections," Technical Gazette, Vol.25, No.3, pp. 776-784, June 2018.

(J3) **Tolić, D.**; Palunko, I.; "Learning Suboptimal Broadcasting Intervals in Multi-Agent Systems," IFAC-PapersOnLine, Vol.50, No.1, pp. 4144-4149, July 2017.

(J4) Mamduhi, M. H.; Molin, A.; **Tolić, D.**; Hirche, S.; "Error-Dependent Data Scheduling in Resource-Aware Networked Control Systems," Automatica, Vol. 81C, pp. 209-216, July 2017.

(J5) **Tolić, D.**; Hirche, S.; "Stabilizing Transmission Intervals for Nonlinear Delayed Networked Control Systems," IEEE Transactions on Automatic Control, Vol.62, No.1, pp. 488-494, January 2017.

(J6) **Tolić, D.**; Sanfelice, R. G.; Fierro, R.; "Input-Output Triggered Control using Lp-Stability over Finite Horizons," International Journal of Robust and Nonlinear Control, Vol. 25, No. 14, pp. 2299-2327, September 2015.

(J7) **Tolić, D.**; Jeličić, V.; Bilas, V.; "Resource Management in Cooperative Multi-Agent Networks Through Self-Triggering," IET Control Theory & Applications, Vol.9, No.6, pp. 915-928, April 2015.

(J8) Haus, T.; Palunko, I.; **Tolić, D.**; Bogdan, S.; Lewis, F. L.; Mikulski, D. G.; "Trust-Based Self-Organizing Network Control," IET Control Theory & Applications, Special Issue: Recent developments in networked control and estimation, Vol.8, No.18, pp. 2126-2135, December 2014.

Books

(B1) **Tolić, D.**; Hirche, S.; "Networked Control Systems with Intermittent Feedback", CRC Press, Boca Raton, FL, 2017.

Book Chapters

(BC1) **Tolić, D.**; Palunko, I.; Ivanović, A.; Car, M.; Bogdan, S.; "Decentralized Cooperative Control in Degraded Communication Environments," in Control of Complex Systems: Theory and Applications, Elsevier, J. Vamvoudakis and S. Jagannathan (ed.), pp. 373-395, Chapter 12, 2016.

(BC2) Petric, F.; **Tolić, D.**; Miklić, D.; Kovačić, Z.; Cepanec, M.; Šimleša, S.; "Towards a Robot-Assisted Autism Diagnostic Protocol: Modelling and Assessment with POMDP," in Intelligent Robotics and Applications, Lecture Notes in Computer Science, Vol. 9245, Springer International Publishing (Switzerland); H. Liu, N. Kubota, X. Zhu, R. Dillmann, D. Zhou (ed.), pp. 82-94, 2015.

(BC3) Cortez, R. A.; **Tolić, D.**; Palunko, I.; Eskandari, N; Oishi, M; Fierro, R.; Wood, J.; "A hybrid framework for prioritized search and adaptive tracking of maneuvering targets using cooperative UAVs," in Intelligent Systems for the AIAA Progress in Aeronautics & Astronautics Series, J. Valasek (ed.), pp. 445 - 469, 2012.

Conferences

(C1) **Tolić, D.**; "Stabilizing Transmissions and Delays in Nonlinear Networked Control Systems: Hybrid Systems with Memory and Lyapunov Approach," IEEE Conference on Decision and Control, pp. 2842-2847, Miami Beach, FL, USA, December 2018.

(C2) **Tolić, D.**; Palunko, I.; "Intermittent Information in Networked Control Systems," International Conference on Smart Systems and Technologies (SST), pp. 269-274, Osijek, Croatia, October 2016, **best paper award**

(C3) Orsag, M.; Haus, T.; **Tolić, D.**; Palunko, I.; Ivanović, A.; Car, M.; Bogdan, S.; "Human-in-the-loop Control of Multi-Agent Aerial Systems," European Control Conference, pp. 2139-2145, Aalborg, Denmark, June-July 2016.

(C4) Petric, F.; **Tolić, D.**; Miklić, D.; Kovačić, Z.; Cepanec, M.; Šimleša, S.; "Towards a Robot-Assisted Autism Diagnostic Protocol: Modelling and Assessment with POMDP," International Conference on Intelligent Robotics and Applications (ICIRA), pp. 82-94, Portsmouth, England, August 2015.

(C5) **Tolić, D.**; Hirche, S.; "Stabilizing Transmission Intervals for Networked Control Systems with Nonlinear Delay Dynamics," IEEE Conference on Decision and Control, pp. 6196-6201, Osaka, Japan, December 2015.

(C6) **Tolić, D.**; Palunko, I.; Ivanović, A.; Car, M.; Bogdan, S.; "Multi-Agent Control in Degraded Communication Environments," European Control Conference, pp. 404-409, Linz, Austria, July 2015.

(C7) Mamduhi, M. H.; **Tolić, D.**; Hirche, S.; "Decentralized Event-Based Scheduling for Shared-Resource Networked Control Systems," European Control Conference, pp. 941-947, Linz, Austria, July 2015.

(C8) Mamduhi, M. H.; **Tolić, D.**; Hirche, S.; "Robust Event-Based Data Scheduling for Resource Constrained Networked Control Systems," IEEE American Control Conference, pp. 4695-4701, Chicago, IL, USA, July 2015.

(C9) **Tolić, D.**; Hirche, S.; "Stabilizing Transmission Intervals and Delays for Nonlinear Networked Control Systems: The Large Delay Case," IEEE Conference on Decision and Control, pp. 1203-1208, Los Angeles, CA, USA, December 2014.

(C10) Mamduhi, M. H.; **Tolić, D.**; Molin, A.; Hirche, S.; "Event-Triggered Scheduling for Stochastic Multi-Loop Networked Control Systems with Packet Dropouts," IEEE Conference on Decision and Control, pp. 2776-2782, Los Angeles, CA, USA, December 2014.

(C11) Haus, T.; Palunko, I.; **Tolić, D.**; Bogdan, S.; Lewis, F. L.; "Decentralized Trust-Based Self-Organizing Cooperative Control," European Control Conference, pp. 1205-1210, Strasbourg, France, June 2014.

(C12) **Tolić, D.**; Hirche, S.; "Stabilizing Transmission Intervals and Delays for Linear Time-Varying Control Systems: The Large Delay Case," Mediterranean Conference on Control and Automation, pp. 686-691, Palermo, Italy, June 2014.

(C13) Jeličić, V.; **Tolić, D.**; Bilas, V.; "Consensus-based Decentralized Resource Sharing between Co-located Wireless Sensor Networks," IEEE Ninth International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP), pp. 1-6, Singapore, April 2014.

(C14) Sorrentino, F.; **Tolić, D.**; Fierro, R.; Picozzi, S.; Gordon, J.R.; Mammoli, A.; "Stability Analysis of a Model for the Market Dynamics of a Smart Grid," IEEE Conference on Decision and Control, pp. 4964-4970, Firenze, Italy, December 2013.

(C15) **Tolić, D.**; "Lp-Stability with Respect to Sets Applied Towards Self-Triggered Communication for Single-Integrator Consensus," IEEE Conference on Decision and Control, pp. 3409-3414, Firenze, Italy, December 2013.

(C16) **Tolić, D.**; Fierro, R.; "Decentralized Output Synchronization of Heterogeneous Linear Systems with Fixed and Switching Topology via Self-Triggered Communication," 2013 IEEE American Control Conference, pp. 4648-4653, Washington DC, June 2013.

(C17) **Tolić, D.**; Fierro, R.; Ferrari, S.; "Optimal Self-Triggering for Nonlinear Systems via Approximate Dynamic Programming," 2012 IEEE Multi-conference on Systems and Control (MSC 2012), pp. 879-884, Dubrovnik, Croatia, October 2012.

(C18) **Tolić, D.**; Sanfelice, R. G.; Fierro, R.; "Self-Triggering in Nonlinear Systems: A Small-Gain Theorem Approach," 20th Mediterranean Conference on Control and Automation, pp. 935-941, Barcelona, Spain, July 2012.

(C19) **Tolić, D.**; Fierro, R.; "Adaptive Sampling for Tracking in Pursuit-Evasion Games," 2011 IEEE Multi-conference on Systems and Control (MSC 2011), pp. 179 - 184, Denver, CO, September 2011.

(C20) **Tolić, D.**; Fierro, R.; "Stability of Feedback Linearization under Intermittent Information: A Target-Pursuit Case," 2011 American Control Conference, pp. 3184 - 3190, San Francisco, CA, June-July 2011.

(C21) Ferrari, S.; Fierro, R.; **Tolić, D.**; "A geometric optimization approach to tracking maneuvering targets using a heterogeneous mobile sensor network," 48th IEEE Conference on Decision and Control, 2009 held jointly with the 2009 28th Chinese Control Conference, pp. 1080-1087, Shanghai, China, December 2009.

(C22) **Tolić, D.**; Fierro, R.; Ferrari, S.; "Cooperative multi-target tracking via hybrid modeling and geometric optimization," 17th Mediterranean Conference on Control and Automation, pp. 440-445, Thessaloniki, Greece, June 2009.

Technical Reports

(T1) **Tolić, D.**; Hirche, S.; "Stabilizing Transmission Intervals for Nonlinear Delayed Networked Control Systems [Extended Version]," technical report, arxiv.org/abs/1604.04421, April 2016.

(T2) **Tolić, D.**; Fierro, R.; "A Comparison of a Curve Fitting Tracking Filter and Conventional Filters under Intermittent Information," Department of Electrical and Computer Engineering, University of New Mexico, October 2010, technical report. [Online]. Available: http://hdl.handle.net/1928/11424

Research Projects

(P1) Participation in the writing and realization phases of the Croatia-Germany bilateral project "Optimal Design and Nonlinear Control of Autonomous Underwater Vehicle (ROADIE)" between University of Dubrovnik and Technical University of Munich, 2018 - 2019

(P2) Participation in the writing and realization phases of the "ConDyS: Control of Dynamical Systems" project funded by Croatian Science Foundation (IP-2016-06-2468), 2017 - 2021

(P3) Participation in the realization phase of the "MORUS: Unmanned system for maritime security and environmental monitoring" project funded by NATO grant SfP - 984807, 2015 - 2018

(P4) Participation in the realization phase of the "EuRoC: European Robotics Challenge, Challenge 3" challenge funded by the European Union's FP7 grant agreement No. 608849, 2014 - 2017

(P5) Participation in the writing and realization phases of the "ADORE: Autism Diagnostic Observation with Robot Evaluator" project funded by Croatian Science Foundation (HRZZ-93743-2014), 2014 - 2018

(P6) Participation in the writing and realization phases of the project titled "Coordination and Control of Multi-Agent Systems". This is a joint project involving the LARICS robotics lab from the University of Zagreb and the research group of Prof. Ji-Feng Zhang from Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Beijing. The duration of the project is two years, 2014 - 2015

(P7) Participation in the writing and realization phases of the AFOSR Grant FA8655-13-1-3055 titled "Human-in-the-loop Control of Multi-Agent Aerial Systems Under Intermittent Communication" funded by Space Technology & Control Sciences European Office of Aerospace Research and Development (EOARD) which is a detachment of Air Force Office of Scientific Research (AFOSR), 2013 - 2015

(P8) Participation in the realization phase of the European Community Seventh Framework Programme under grant No. 285939 (ACROSS), 2012-2014

(P9) Participation in the realization phase of "Collaborative Research: An Adaptive Dynamic Programming Approach to the Coordination of Heterogeneous Robotic Sensors Networks" funded by National Science Foundation (NSF), Award 1027775, 2010-2012

(P10) Participation in the realization phase of "CAREER: Coordination of Dynamic Networks - A Hybrid System Approach" funded by National Science Foundation (NSF), Award 0811347, 2008 - 2010

Programming

C, C++, Java, Matlab, Simulink, Robot Operating System (ROS), Python, Mathematica, LaTeX 2_ε

Invited Talks

- "Towards Optimal Information Exchange Instants in Multi-Agent Systems", Centre de Recherche en Automatique de Nancy (CRAN), Nancy, France, June 26, 2017.
- "Towards Optimal Information Exchange Instants in Multi-Agent Systems", Technical University of Munich, Munich, Germany, June 13, 2017.
- "Intermittent and Delayed Information in Nonlinear Networked Control Systems", Electrical and Electronic Engineering Department, University of Melbourne, Australia, November 1, 2016.
- "Optimal Intermittent Feedback in Networked Control Systems via Approximate Dynamic Programming", Department of Automation, Technical University of Cluj-Napoca, Romania, June 16, 2016.
- "Nonlinear Networked Control Systems with Intermittent and Delayed Information", Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Beijing, China, December 2, 2015.
- "Networked Control Systems: Intermittent and Delayed Information", Faculty of Electrical Engineering, University of Osijek, Osijek, Croatia, March 16, 2015.
- "Realistic Information in Control Systems – Intermittent, Delayed and Distorted", Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Beijing, China, September 4, 2014.
- "Self-Triggering for Nonlinear Systems Employing Lp-stability", Technical University of Munich, Munich, Germany, October 30, 2013.

Review Activities

Journals

- IFAC Automatica (2012, 2015, 2016, 2017, 2018)
- IEEE Transactions on Automatic Control (TAC 2009, 2012, 2013, 2014, 2015, 2016, 2017, 2018)
- IEEE Control Systems Letters (L-CSS 2017, 2018)
- IEEE Transactions on Systems, Men, and Cybernetics - Part B (2009, 2010) → IEEE Transactions on Cybernetics (TCYB 2017, 2018, 2019)
- IEEE Transactions on Control Systems Technology (TCST 2016, 2017)
- International Journal of Robust and Nonlinear Control (IJRNC 2010, 2018)
- IEEE Access (2018)
- Communications in Nonlinear Science and Numerical Simulation (CNSNS 2016, 2018)
- Nonlinear Analysis: Hybrid Systems (NAHS 2015, 2016)
- International Journal of Control (TCON 2018)
- Journal of Intelligent and Robotic Systems (JINT 2011)
- International Journal of Robotics Research (IJRR 2012)
- Engineering Applications of Artificial Intelligence (EAAI 2018)
- IEEE Control Systems Magazine (CSM 2012)
- IET Control Theory & Applications (IET CT&A 2014, 2017, 2018)
- IEEE Transactions on Control of Network Systems (TCNS 2014, 2015, 2016)
- Transactions of the Institute of Measurement and Control (TIMC 2012, 2013, 2014, 2015, 2016, 2017, 2018)
- IEEE Transactions on Industrial Informatics (TII 2018)
- Asian journal of Control (AJC 2018)
- IEEE Transactions on Circuits and Systems I (TCAS-I 2012)
- Control and Intelligent Systems (CIS 2017)
- Advances in Mechanical Engineering (AME 2017)
- Journal of Control Theory and Technology (CTT 2014)
- Journal of Defense Modeling and Simulation (JDMS 2010)
- Chaos, Solitons & Fractals by Elsevier (CHAOS 2017)
- AUTOMATIKA: Journal for Control, Measurement, Electronics, Computing and Communications (2014, 2015, 2018)
- RIThink (2017)
- Interdisciplinary Description of Complex Systems (INDECS 2017)

Conferences

- IEEE International Conference on Robotics and Automation (ICRA 2010, 2012)
- IEEE International Conference on Intelligent Robots and Systems (IROS 2010, 2012, 2015)
- IEEE Conference on Decision and Control (CDC 2011, 2012, 2013, 2014, 2015, 2016, 2017)
- IEEE American Control Conference (ACC 2013, 2014, 2015, 2017)
- European Control Conference (ECC 2013, 2014, 2015, 2016, 2018, 2019)
- IEEE Multi-conference on Systems and Control (MSC 2011, 2012, 2013, 2014)
- International Conference on Hybrid Systems: Computation and Control (HSCC 2014)
- IEEE Mediterranean Conference on Control and Automation (MED 2015, 2018)
- IFAC World Congress (IFAC WC 2017)
- Asian Control Conference (ASCC 2017)
- Neural Information Processing Systems (NIPS 2018)
- IEEE Conference on Control Technology (CCTA 2017)
- International Conference on Smart Systems and Technologies (SST 2017)
- International Conference on Information, Communication and Automation Technologies (ICAT 2017)
- IEEE Haptics Symposium (HAPTICS 2018)

Language skills

- Croatian - native
- English - excellent in writing and speaking
- Spanish - intermediate in writing and speaking
- German - basic in writing and speaking