Ali Pakniyat

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ACADEMIC APPOINTMENTS

University of Alabama, Tuscaloosa, AL — *2021 - present*
Assistant Professor, Department of Mechanical Engineering

Georgia Institute of Technology, Atlanta, USA — *2019 - 2021*
Postdoctoral Research Fellow, Institute for Robotics and Intelligent Machines

University of Michigan, Ann Arbor, USA — *2017 - 2019*
Postdoctoral Research Fellow, Department of Mechanical Engineering

McGill University, Montreal, Canada — *2016 - 2017*
Lecturer, Department of Electrical and Computer Engineering

EDUCATION

McGill University, Montreal, Canada — *2011 – 2016*
Doctor of Philosophy, Electrical Engineering

Sharif University of Technology, Tehran, Iran — *2008 – 2010*
Master of Science, Mechanical Engineering

Shiraz University, Shiraz, Iran — *2004 – 2008*
Bachelor of Science, Mechanical Engineering

RESEARCH AREAS

Control Theory: Optimization and Optimal Control, Hybrid Systems, Stochastic Processes, Multi-Agent Systems, Mean-Field Games

Control Practice: Autonomous Driving, Vehicle Electrification, Robotics, Micro Electrical-Mechanical Systems (MEMS), Mathematical Finance, Large-Scale Networks

PUBLICATIONS

Published Journal Papers

[J7] **A. Pakniyat** and P. E. Caines, "On the Hybrid Minimum Principle: The Hamiltonian and Adjoint Boundary Conditions," *IEEE Transactions on Automatic Control*, vol. 66, no. 3, pp. 1246–1253, 2021

[J6] D. Firoozi, **A. Pakniyat**, and P. E. Caines, "A Class of Hybrid LQG Mean Field Games with State-Invariant Switching and Stopping Strategies," *(accepted for publication in) Automatica*, 2021

[J5] **A. Pakniyat** and P. E. Caines, "On the Relation between the Minimum Principle and Dynamic Programming for Classical and Hybrid Control Systems," *IEEE Transactions on Automatic Control*, vol. 62, no. 9, pp. 4347–4362, 2017

[J4] **A. Pakniyat** and P. E. Caines, "Hybrid Optimal Control of an Electric Vehicle with a Dual-Planetary Transmission," *Nonlinear Analysis: Hybrid Systems*, vol. 25, pp. 263–282, 2017

[J3] M. S. R. Mousavi, **A. Pakniyat**, T. Wang, and B. Boulet, "Seamless Dual Brake Transmission For Electric Vehicles: Design, Control and Experiment," *Mechanism and Machine Theory*, vol. 94, pp. 96–118, 2015

[J2] **A. Pakniyat** and H. Salarieh, "A Parametric Study on Design of a Microrate-Gyroscope with Parametric Resonance," *Measurement*, vol. 46, no. 8, pp. 2661–2671, 2013

[J1] **A. Pakniyat**, H. Salarieh, and A. Alasty, "Stability Analysis of a New Class of MEMS Gyroscopes with Parametric Resonance," *Acta Mechanica*, vol. 223, no. 6, pp. 1169–1185, 2012

Published Journal/Conference Papers

[JC4] **A. Pakniyat** and P. E. Caines, "A Class of Linear Quadratic Gaussian Hybrid Optimal Control Problems with Realization–Independent Riccati Equations," *IFAC-PapersOnLine*, vol. 50, no. 1, pp. 2241–2246, 2017, also appeared in Proceedings of the International Federation of Automatic Control 20th World Congress, Toulouse, France

[JC3] **A. Pakniyat** and P. E. Caines, "Time Optimal Hybrid Minimum Principle and the Gear Changing Problem for Electric Vehicles," *IFAC-PapersOnLine*, vol. 48, no. 27, pp. 187–192, 2015, also appeared in Proceedings of the 5th IFAC Conference on Analysis and Design of Hybrid Systems, Atlanta, GA, USA

[JC2] **A. Pakniyat** and P. E. Caines, "On the Relation between the Hybrid Minimum Principle and Hybrid Dynamic Programming: A Linear Quadratic Example," *IFAC-PapersOnLine*, vol. 48, no. 27, pp. 169–174, 2015, also in Proceedings of the 5th IFAC Conference on Analysis and Design of Hybrid Systems, Atlanta, GA, USA

[JC1] **A. Pakniyat** and P. E. Caines, "On the Minimum Principle and Dynamic Programming for Hybrid Systems," *IFAC Proceedings Volumes*, vol. 47, no. 3, pp. 9629–9634, 2014, also appeared in Proceedings of the International Federation of Automatic Control 19th World Congress, Cape Town, South Africa

Patent

[P1] B. Boulet, M. S. R. Mousavi, H. V. Alizadeh, and **A. Pakniyat**, "Seamless Transmission Systems and Methods for Electric Vehicles," Jul. 11 2017, US Patent US 9,702,438 B2

Published Conference Papers

[C16] **A. Pakniyat** and P. Tsiotras, "Steering the State of Linear Stochastic Systems with Partial Observations," *(to appear in Proceedings of) the IEEE Conference on Decision and Control, Austin, USA*, 2021

[C15] K. P. Hawkins, **A. Pakniyat**, and P. Tsiotras, "On the Time Discretization of the Feynman-Kac Forward-Backward Stochastic Differential Equations for Value Function Approximation," *(to appear in Proceedings of) the IEEE Conference on Decision and Control, Austin, USA*, 2021

[C14] K. P. Hawkins, **A. Pakniyat**, E. Theodorou, and P. Tsiotras, "Forward-Backward Rapidly-Exploring Random Trees for Stochastic Optimal Control," *(to appear in Proceedings of) the IEEE Conference on Decision and Control, Austin, USA*, 2021

[C13] **A. Pakniyat** and P. Tsiotras, "Steering the State of Linear Stochastic Systems: A Constrained Minimum Principle Formulation," in *Proceedings of the IEEE American Control Conference, New Orleans, USA*, 2021, pp. 1296–1301

[C12] **A. Pakniyat** and R. Vasudevan, "A Convex Duality Approach to Optimal Control of Killed Markov Processes," in *Proceedings of the 58th IEEE Conference on Decision and Control, Nice, France*, 2019, pp. 8216–8223

[C11] D. Firoozi, **A. Pakniyat**, and P. E. Caines, "A Mean Field Game - Hybrid Systems Approach to Optimal Execution Problems in Finance with Stopping Times," in *Proceedings of the 56th IEEE Conference on Decision and Control, Melbourne, Australia*, 2017, pp. 433–441

[C10] **A. Pakniyat** and P. E. Caines, "On the Stochastic Minimum Principle for Hybrid Systems," in *Proceedings of the 55th IEEE Conference on Decision and Control, Las Vegas, NV, USA*, 2016, pp. 1139–1144

[C9] **A. Pakniyat** and P. E. Caines, "On the Minimum Principle and Dynamic Programming for Hybrid Systems with Low Dimensional Switching Manifolds," in *Proceedings of the 54th IEEE Conference on Decision and Control, Osaka, Japan*, 2015, pp. 2567–2573

[C8] M. S. R. Mousavi, **A. Pakniyat**, M. K. Helwa, and B. Boulet, "Observer-Based Backstepping Controller Design for Gear Shift Control of a Seamless Clutchless Two-Speed Transmission for Electric Vehicles," in *Proceedings of the IEEE Vehicle Power and Propulsion Conference (VPPC), Montreal, QC, Canada*, 2015, pp. 1–6

[C7] **A. Pakniyat** and P. E. Caines, "On the Relation between the Minimum Principle and Dynamic Programming for Hybrid Systems," in *Proceedings of the IEEE Conference on Decision and Control, Los Angeles, USA*, 2014, pp. 19–24

[C6] **A. Pakniyat** and P. E. Caines, "The Gear Selection Problem for Electric Vehicles: An Optimal Control Formulation," in *Proceedings of the 13th International Conference on Control Automation Robotics & Vision ICARCV, Marina Bay Sands, Singapore.* IEEE, 2014, pp. 1261–1266

[C5] M. S. R. Mousavi, **A. Pakniyat**, and B. Boulet, "Dynamic Modeling and Controller Design for a Seamless Two-Speed Transmission for Electric Vehicles," in *Proceedings of the 2014 IEEE Conference on Control Applications, Antibes, France*, 2014, pp. 635–640

[C4] **A. Pakniyat** and P. E. Caines, "The Hybrid Minimum Principle in the Presence of Switching Costs," in *Proceedings of the 52nd IEEE Conference on Decision and Control, Florence, Italy*, 2013, pp. 3831–3836

[C3] **A. Pakniyat**, H. Salarieh, G. Vossoughi, and A. Alasty, "A Modification on Performance of MEMS Gyroscopes by Parametro-Harmonic Excitation," in *Proceedings of the 10th ASME Biennial Conference on Engineering Systems Design and Analysis, Istanbul, Turkey*, 2010, pp. 433–441

[C2] **A. Pakniyat**, H. Salarieh, and A. Alasty, "Stability Analysis of a Novel MEMS Gyroscope Actuated by Parametric Resonance Using Floquet Theory," in *Proceedings of the 3rd Conference on Nano-Structures, Kish Island, Persian Gulf, Iran*, 2010, pp. 1219–1221

[C1] **A. Pakniyat** and M. Eghtesad, "Solving Differential Equations using Wavelet Transform," in *Proceedings of the 17th Annual International Conference on Mechanical Engineering, Tehran, Iran*, 2010, pp. 1–6, (in Persian)

Under Review and In-Preparation Journal Papers

[U5] K. P. Hawkins, **A. Pakniyat**, E. Theodorou, and P. Tsiotras, "Solving Feynman-Kac Forward Backward SDEs Using McKean-Markov Branched Sampling," *(under review for publication in) the IEEE Transactions on Automatic Control*, arXiv:2006.12444

[U4] K. P. Hawkins, **A. Pakniyat**, and P. Tsiotras, "Value Function Estimators for Feynman-Kac Forward-Backward SDEs in Stochastic Optimal Control," *(under review for publication in) Automatica*

[U3] **A. Pakniyat** and P. E. Caines, "The Stochastic Hybrid Minimum Principle."

[U2] **A. Pakniyat** and R. Vasudevan, "A Convex Duality Approach to Hybrid Dynamic Programming."

[U1] **A. Pakniyat** and P. Tsiotras, "Optimal State Steering for Stochastic Hybrid Systems."

SELECTED HONOURS AND AWARDS

- ▷ Canadian Marconi Graduate Award 2017
- ▷ Automotive Partnership Canada (APC) – Natural Sciences & Engineering Research Council (NSERC) 2012–2016
- ▷ MEDA (McGill Engineering Doctoral Award) 2011–2014
- ▷ GERAD (Groupe d'Études et de Recherche en Analyse des Décisions) Doctoral Fellowship 2015
- ▷ Graduate Excellence Award in Engineering – McGill University 2011–2014
- ▷ IEEE-CSS (Control Systems Society) Travel Award 2014
- ▷ GREAT (Graduate Research Enhancement and Travel) – McGill University 2014
- ▷ Ranked 2nd among 57 students in the program of Applied Mechanics, and 3rd among 130 students in the M.Sc. program of Mechanical Engineering at Sharif University of Technology 2008–2010
- ▷ Ranked 1st among 80 students in the B.Sc. program of Mechanical Engineering at Shiraz University 2004–2008

TEACHING EXPERIENCES

Course Lecturer

McGill University, Course Instructor
- ECSE 493 **Control and Robotics Laboratory**, Winter 2016, 2017
- ECSE 205 **Probability and Statistics for Engineers**, Fall 2016,Winter 2017

Teaching Assistant

McGill University, Teaching Assistant
- ECSE 516 **Nonlinear and Hybrid Control Systems**, Winter 2013, 2017
- ECSE 506 **Stochastic Control and Decision Theory**, Winter 2014
- ECSE 500 **Mathematical Foundations of Systems**, Fall 2013, 2015
- ECSE 493 **Control and Robotics Laboratory**, Winter 2014, 2015
- ECSE 443 **Introduction to Numerical Methods in Electrical Engineering**, Winter 2014, 2015
- ECSE 404 **Control Systems**, Fall 2013, 2014, 2015, 2016

Sharif University of Technology, Teaching Assistant
- MECH 28586 **Robust Control**, Fall 2010
- MECH 28416 **Automatic Control**, Spring 2010, Fall 2010

Shiraz University, Teaching Assistant
- MECH 100531241 **Mechanical Vibrations**, Spring 2008
- MECH 100531221 **Dynamics of Machinery**, Spring 2008
- MECH 100531171 **Machine Design II**, Fall 2007
- MECH 100531161 **Machine Design I**, Spring 2007
- MECH 100531071 **Dynamics**, Fall 2006

INVITED TALKS

2020-03-26 Arizona State University, School for Engineering of Matter, Transport and Energy Seminar, Tempe, USA
2020-03-18 University of Michigan – Dearborn, Electrical & Computer Engineering Department Seminar, Dearborn, USA
2019-05-30 CIM – GERAD Informal Systems Seminar (ISS), Montreal, Canada
2019-05-27 Queen's University Control Theory Seminar, Kingston, Canada
2019-04-09 Center for Control, Dynamical Systems, and Computation (CCDC) Seminar, Santa Barbara, USA
2018-10-13 The 2018 Midwest Optimization Meeting, Oxford (OH), USA
2018-06-07 University College Dublin, School of Electrical and Electronic Engineering, Dublin, Ireland
2018-04-25 Michigan Postdoctoral Association of the College of Engineering (MPACE) Seminar, Ann Arbor, USA
2018-01-30 Michigan Robotics Colloquium, Ann Arbor, USA
2017-09-08 University of California, Santa Barbara, Department of Mechanical Engineering, Santa Barbara, USA
2017-09-05 Stanford University, Department of Aeronautics and Astronautics, Stanford, USA
2017-01-30 University of Michigan, Department of Mechanical Engineering, Ann Arbor, USA
2017-01-06 University of California, Irvine, Aeronatics, Dynamics and Control Lab Seminar Irvine, USA
2016-07-21 IEEE Montreal – Concordia University, Montreal, Canada
2016-05-11 The 7th Biannual Meeting on System and Control Theory, Kingston, Canada
2014-05-05 The 6th Biannual Meeting on System and Control Theory, Waterloo, Canada

SELECTED RESEARCH EXPERIENCES

Dynamics and Control Systems Laboratory (DCSL), Georgia Tech

- **Optimal Steering of Stochastic Hybrid Systems**: Development of control algorithms that guarantee the realization of pre-specified probability distributions of the state at a terminal time. A case of particular interest is the control energy minimization for the landing of Mars rover, including the optimization over the deployment of the parachute.
- **Forward-Backward Rapidly-Exploring Random Trees (FB-RRT)**: Introduction and employment of backward RRTs (in contrast to the conventional forward RRTs) in establishing conditional expectations in the Monte Carlo explorations of optimal optimal policies for nonlinear stochastic control problems.

Robotics and Optimization for the Analysis of Human Motion (ROAHM), Univ. of Michigan

- **Sum of Squares (SOS) Polynomial Optimization Algorithms for Hybrid Systems**: Development of computationally efficient numerical algorithms for polynomial hybrid control systems. Particular goals in the optimization are the determination of (i) the maximal sub-solution polynomial solution to the Hamilton-Jacobi inequalities, and (ii) the hybrid Lyapunov functions with the largest region of attraction.
- **Convex Duality Relations between Measure and Function in Hybrid Optimal Control Problems:** Establishing a control-theoretic framework for the study of hybrid systems based upon the disrtibution of trajectories under variations of the control law (in comparison with the conventional trajectory viewpoint corresponding to fixed input laws; this formulation results in the representation of optimal control problems as convex linear programs in the space of measures that can be efficiently solved by semi-definite programming optimization toolboxes.

Groupe d'Études et de Recherche en Analyse des Décisions[1] (GERAD), McGill University

- **Hybrid Mean Field Games (H-MFG):** Developing computationally-efficient methods to determine the combined optimal stopping and optimal trading policies for a financial institution together with a large number of high-frequency traders (HFT), each with asymptotically negligible influence in the market, who can join or quit the market (optimally) at any time. The large number of interactions between these competing decision makers are substituted with an aggregate effect of others, referred to as the system's "mean field", whose dynamics is presented as a hybrid system.

Automotive Partnership Canda (APC), McGill University

- **Dual Planetary Transmission (DPT) for Electric Vehicles (EVs):** Design and the control a DPT mechanism exclusively designed for EVs (patented [P1]) capable of transmitting power from the motor to wheels, not only in fixed gear-ration modes, but also during the transition between the gears.
- **Hybrid Control Algorithms for the DPT:** Development of novel control algorithms for MoGen (Electric Motor and Generator) together with the brakes operating the transitioning phase between the gears for three distinct objectives of (i) no output speed drop, (ii) fastest acceleration, and (iii) the minimization of energy consumption of the EV. An unanticipated phenomenon of note that appears in the solution of (iii) is the presence of power regeneration as a part of the acceleration task for the minimization of the energy consumption.

Centre for Intelligent Machines (CIM), McGill University

- **A Unified Hybrid Systems Framework:** Developing a unified general framework that permits (a) the presence of both types of autonomous and controlled switchings, (b) the possibility of jumps in the state at switching instances, and (c) the possibility of dimension changes in the state space.
- **Hybrid Minimum Principle (HMP):** Establishing a new version of the HMP by needle-variations methodology permitting the features (a), (b) and (c) above. As an important consequence of the new results, a novel HMP-MAS (Multiple Autonomous Switchings) algorithm is presented.
- **Hybrid Dynamic Programming (HDP) and the HMP–HDP Relationship:** Establishing a new version of HDP permitting the features (a), (b) and (c) above and proving the adjoint-gradient relationship under mild regularity requirements for the differentiability of the value function.
- **Stochastic Hybrid Minimum Principle (SHMP):** Establishing the first version of the SHMP in the presence of state-dependent diffusions (interactions with a Brownian / Wiener process) permitting the features (a), (b) and (c) above. The significant aspect of this work is the consideration of switching manifolds of equality type (almost-surely), i.e. $m(x) \overset{a.s.}{=} 0$ that, in the literature, had only been guaranteed in the form of expectations, i.e. $\mathbb{E}[m(x)] = 0$.

Center of Excellence in Design, Robotics, and Automation (CEDRA), Sharif Univ. of Tech.

- **Parametrically Resonated MEMS Gyroscopes:** Dynamic analysis, bifurcation and chaos investigation of vibratory Micro Electro–Mechanical Systems (MEMS). A significant result of this work is the identification of unanticipated resonance modes in parametrically resonated MEMS gyroscopes that produce significantly high output amplitudes while providing robustness to manufacturing imperfections.

[1] Group for Study and Research in Decision Analysis

SELECTED LEADERSHIP AND VOLUNTEER EXPERIENCES

Mentor, Association for Women in Science (AWIS) - University of Michigan 2017 – 2019
Chair, Chapter 12 (Control Systems) - IEEE SEM (Southeast Michigan) Section 2018
Technical Judge, Emerging Research Competition in Engineering Graduate Symposium - Univ. of Michigan 2018
Seminar Coordinator, Informal Systems Seminars (ISS) - McGill University 2012 – 2017
Charity Fundraiser, Omid Group - Hope for Children with Cancer 2013–2016

SELECTED TRAINING EXPERIENCES

Technical Research Training
2019 *Southeast Controls Conference*, Georgia Institute of Technology
2018 *Stochastic Control and its Application*, IEEE Control Systems Society
2018 *Midwest Optimization Meeting*, Miami University
2018 *Princeton Day of Optimization*, Princeton University
2018 *Midwest Robotics Workshop*, Toyota Technological Institute at Chicago
2018 *Meeting on System and Control Theory*, University of Toronto
2018 *Midwest Workshop on Control and Game Theory*, Michigan State University
2017 *Mean Field Games Workshop*, Institute for Pure and Applied Mathematics, Univ. of California, Los Angeles
2016 *Aerospace Summer School*, Concordia University
2016 *Meeting on System and Control Theory*, Queen's University
2015 *Workshop on Dynamic Games in Management Science*, GERAD – HEC Montréal
2015 *Mathematical Cybernetics: Hybrid, Stochastic and Decentralized Systems*, Carlton University
2014 *Symposium on Advanced Electric Vehicle Drivetrains*, McGill University – IEEE
2014 *Meeting on System and Control Theory*, University of Waterloo

Teaching Training
2018 *Postdoctoral Course on College Teaching in STEM*, University of Michigan
2017 *Motivating Engineering Students: Strategies to Increase Engagement*, University of Michigan
2017 *Perspectives on Teaching: A Faculty Panel*, University of Michigan
2017 *Workshop on Graduate Supervision*, McGill University
2011 *Graduate Teaching Workshop*, McGill University

General Training
2017 *Academic Identity Management*, University of Michigan
2017 *Research Integrity Workshop*, McGill University
2016 *NASA Engineering and Science Activities*, IEEE–Montreal
2016 *Workshop on How to Organize an IEEE Event*, IEEE Panel of Conference Organizers (POCO)
2014 *Workshop on Basic Business Skills for Non-Business Graduate Students*, McGill University
2010 *Workshop on Invention: Technology Development and Commercialization*, University of Southern California and Sharif University of Technology

REVIEW SERVICES

Journals: • IEEE Transactions on Automatic Control (TAC), • Automatica, • Systems & Control Letters (SCL), • SIAM Journal on Control and Optimization (SICON), • IEEE Control Systems Letters (L-CSS), • Nonlinear Analysis: Hybrid Systems (NAHS), • IEEE Transactions on Systems, Man, and Cybernetics: Systems (SMC), • IEEE Transactions on Control of Network Systems (CONES), • Nonlinear Dynamics (NODY), • Sensors - MDPI

Conferences: • IEEE Conference on Decision and Control (CDC), • IEEE American Control Conference (ACC), • IFAC World Congress, • ACM Conference on Hybrid Systems: Computation and Control (HSCC), • IEEE European Control Conference (ECC), • ISME International Conference on Mechanical Engineering

SELECTED REFERENCES

Peter E. Caines, Professor, Department of Electrical and Computer Engineering, McGill University
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Aditya Mahajan, Associate Professor, Department of Electrical and Computer Engineering, McGill University
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