

# PEDRO HESPANHOL

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## PROFESSIONAL SUMMARY

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My research is focused on the interplay between control, learning, and optimization, with emphasis on autonomous systems applications and multi-agent systems. I have work experience in both prototyping (Python, Matlab) and developing production-level code (C, C++) of embedded algorithms for real-time applications, including nonlinear, hybrid, and stochastic systems, as well as a patent on an efficient algorithm for Model Predictive Control based on second-order methods. During Spring 2020, I have designed and taught a course on approximate dynamic programming and deep reinforcement learning theory and algorithms. My current research interests include: real-time optimal control, reinforcement learning, and algorithmic mechanism design.

## CURRENT POSITION

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PhD Student, Industrial Engineering and Operations Research, UC Berkeley

## EDUCATION

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**PhD, Industrial Engineering and Operations Research, UC Berkeley, 2020**

Minors: Statistics and Economics

Advisor: [Anil Aswani](#)

**MS, Industrial Engineering and Operation Research, UC Berkeley, 2016**

**BS, Industrial Engineering, Pontifical Catholic University Of Rio De Janeiro, 2014**

Minor: Risk Analysis

## RESEARCH AREAS AND COURSEWORK

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### Optimization Theory and Optimal Control

Math Programming I & II, Computational Optimization, Graph Algorithms and Network Flows, Predictive Control, Learning and Optimization, Applied Dynamic Programming

### Statistical Learning and Deep Learning

Statistical Learning Theory, Deep Time-Series Learning, Deep Reinforcement Learning

### Game Theory and Mechanism Design

Microeconomics and Game Theory, Mechanism Design and Agency Theory

### Financial Engineering and Stochastic Processes

Financial Engineering I & II, Stochastic Processes I & II

## JOURNAL PUBLICATIONS

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### Sensor Switching Control Under Attacks Detectable by Finite Sample Dynamic Watermarking Tests

Pedro Hespanhol, Matthew Porter, Ram Vasudevan, and Anil Aswani

Submitted to *IEEE Transactions on Automatic Control*, under 2nd round of review (2020)

preprint: <https://arxiv.org/abs/1909.00014>

### **Statistical Consistency of Set-Membership Estimator for Linear Systems**

Pedro Hespanhol and Anil Aswani

*IEEE Control Systems Letters* (2020)

<https://doi.org/10.1109/LCSYS.2020.2990998>

### **Detecting Generalized Replay Attacks via Time-Varying Dynamic Watermarking**

Matthew Porter, Pedro Hespanhol, Anil Aswani, Matthew Johnson-Roberson, and Ram Vasudevan

Submitted to *IEEE Transactions on Automatic Control*, under 2nd round of review (2020)

preprint: <https://arxiv.org/abs/1909.08111>

### **Adjoint-Based SQP Method with Block-Qise Quasi-Newton Jacobian Updates for Nonlinear Optimal Control**

Pedro Hespanhol and Rien Quirynen

*Optimization Methods and Software* (2019)

<https://doi.org/10.1080/10556788.2019.1653869>

## **CONFERENCE PAPERS**

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### **Hypothesis Testing Approach to Detecting Collusion in Competitive Environments**

Pedro Hespanhol and Anil Aswani

In Proceedings of *International Conference on Performance Evaluation Methodologies and Tools (Valuetools)*, to appear (2020)

preprint: <https://arxiv.org/abs/2003.09967>

### **Detecting Deception Attacks on Autonomous Vehicles via Linear Time-Varying Dynamic Watermarking**

Matthew Porter, Sidhartha Dey, Arnav Joshi, Pedro Hespanhol, Anil Aswani, Matthew Johnson-Roberson, and Ram Vasudevan

In Proceedings of *Conference on Control Technology and Applications (CCTA)*, to appear (2020)

preprint: <https://arxiv.org/abs/2001.09859>

### **Surrogate Optimal Control for Strategic Multi-Agent Systems**

Pedro Hespanhol and Anil Aswani

In Proceedings of *Conference on Decision and Control (CDC)* (2019)

<https://doi.org/10.1109/CDC40024.2019.9029475>

### **A Structure Exploiting Branch-and-Bound Algorithm for Mixed-Integer Model Predictive Control**

Pedro Hespanhol, Rien Quirynen, and Stefano Di Cairano

In Proceedings of *European Control Conference (ECC)* (2019)

<https://doi.org/10.23919/ECC.2019.8796242>

### **Simulation and Real-World Evaluation of Attack Detection Schemes**

Matthew Porter, Arnav Joshi, Pedro Hespanhol, Anil Aswani, Matthew Johnson-Roberson, and Ram Vasudevan

In Proceedings of *American Control Conference (ACC)* (2019)

<https://doi.org/10.23919/ACC.2019.8815318>

### **Statistical Watermarking for Networked Control Systems**

Pedro Hespanhol, Matthew Porter, Ram Vasudevan, and Anil Aswani

In Proceedings of *American Control Conference (ACC)* (2018)

<https://doi.org/10.23919/ACC.2018.8431569>

### **Quasi-Newton Jacobian and Hessian Updates for Pseudospectral based NMPC**

Pedro Hespanhol and Rien Quirynen

In Proceedings of *International Federation of Automatic Control (IFAC)* (2018)

<https://doi.org/10.1016/j.ifacol.2018.10.169>

## **A Real-Time Iteration Scheme with Quasi-Newton Jacobian Updates for Nonlinear Model Predictive Control**

Pedro Hespanhol and Rien Quirynen

In Proceedings of *European Control Conference (ECC)* (2018)

<https://doi.org/10.23919/ECC.2018.8550541>

## **Family-Personalized Dietary Planning with Temporal Dynamics**

Pedro Hespanhol and Anil Aswani

In Proceedings of *American Control Conference (ACC)* (2018)

<https://doi.org/10.23919/ACC.2018.8430885>

## **Impact of Occupancy Modeling and Horizon Length on HVAC Controller Efficiency**

Christian Garaza, Pedro Hespanhol, Yonatan Mintz, Jhoanna Rhodette Pedrasa, and Anil Aswani

In Proceedings of *European Control Conference (ECC)* (2018)

<https://doi.org/10.23919/ECC.2018.8550389>

## **Dynamic Watermarking for General LTI Systems**

Pedro Hespanhol, Matthew Porter, Ram Vasudevan, and Anil Aswani

In Proceedings of *Conference on Decision and Control (CDC)* (2017)

<https://doi.org/10.1109/CDC.2017.8263914>

## **PATENTS**

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### **Method with quasi-Newton Jacobian updates for nonlinear predictive control**

Rien Quirynen and Pedro Hespanhol

Sep 2019 - patent number: US10409233B2

<https://patents.google.com/patent/US10409233B2/en>

## **WORK HISTORY**

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### **UBER ATG, Pittsburgh, PA**

May 2020

*Autonomy Engineer II*

- *\*Full time position rescinded due to Covid-19 - Referral letter available upon request*
- Incoming full-time employee on their Motion Planning team specializing in developing real-time optimal control algorithms for vehicle planning, decision-making, and motion control.

### **University Of California Berkeley, Berkeley, CA**

January 2020 - May 2020

*Course Instructor*

- Lead Course Instructor of IEOR 265 - Learning and Optimization (Spring 2020).  
Designed a graduate-level course which covers approximate dynamic programming, deep reinforcement learning, and learning-based model predictive control (LBMPC).
- Course materials available on website: <http://pedrohespanhol.com>

### **UBER ATG, Pittsburgh, PA**

May 2019 - August 2019

*Software Engineering Intern*

- Worked on the Motion Planning team developing new optimal control algorithms and software in C++ for real-time operation of autonomous vehicles.
- Validated methods with rigorous test cases to showcase improvement in vehicle/system performance.

### **Mitsubishi Electric Research Laboratories (MERL) Cambridge, MA**

May 2018 - August

2018

*Research Intern*

- Research on mixed-integer optimization algorithms. Developed efficient mixed integer software for fast online optimal control problems, focusing on implementation in embedded platforms.
- Developed algorithm in C and evaluated its performance on realistic optimal control problems, beating state-of-art solvers/methods across several different problems.

**Mitsubishi Electric Research Laboratories (MERL) Cambridge, MA** June 2017 - September 2017

*Research Intern*

- Worked on research of efficient optimization algorithms tailored to solve non-linear optimal control problems, with emphasis on computational performance and solution tractability.
- Worked on implementation in C/C++ of such algorithms in embedded platforms, focusing on rigorously analyzing computation times and memory usage of the developed methods.

**University Of California Berkeley, Berkeley, CA**

January 2017 - December 2019

*Graduate Student Instructor*

- Graduate Student Instructor for IEOR 262A - Math Programming I. Graduate-level course which covers linear and nonlinear optimization theory and algorithms.
- Graduate Student Instructor for IEOR 165 - Engineering Statistics, Quality Control, and Forecasting. Senior undergraduate-level course which covers classical statistical and modern machine learning techniques applied to several industrial applications.
- Graduate Student Instructor for IEOR 151 - Service Design and Operation Analysis. Senior undergraduate-level course which covers analysis and modeling of service-based systems.

**PSR - Energy Consulting and Analytics Rio de Janeiro, Brazil** August 2014 - August 2015

*Analyst*

- Worked in development team (SDDP software): Extensive use of C/C++ and high-level mathematical modeling languages and statistical tools to improve software performance, decrease run-time, and solution output
- Programmed optimization algorithm for HERA software: HERA is a geographical and financial analysis software to evaluate construction of hydro power-plants. HERA team won ENGIE Brazil Innovation Prize in 2015
- Developed mathematical models and algorithms to support decision making in: energy trading, portfolio optimization, operation planning and capacity expansion in power systems

**NexO Rio de Janeiro, Brazil**

January 2012 to July 2013

*Analyst Intern*

- Worked in development team: Implemented mathematical algorithms to optimally operate oil refineries. Work done together with CENPES (Petrobras' Research Center)
- Developed graphical interfaces to show refineries products flows

## PRESENTATIONS AND INVITED TALKS

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**Surrogate Optimal Control for Strategic Multi Agent Systems**

*Professor S. Shankar Sastry semiautonomous group at UC Berkeley*

**A Structure Exploiting Branch-and-bound Algorithm For Mixed-integer Model Predictive Control**

*INFORMS Annual Meeting, Seattle, WA, 2019.*

**Statistically-Consistent Identification of Switched Linear Systems**

*INFORMS Annual Meeting, Seattle, WA, 2019.*

### **Surrogate Optimal Control for Strategic Multi-Agent Systems**

*58th IEEE Conference on Decision and Control, Nice, France, December 11-13, 2019.*

### **Statistical Watermarking for Networked Control Systems**

*Annual American Control Conference, Milwaukee, USA, June 27-29, 2018.*

### **Newton Jacobian Updates for Nonlinear Model Predictive Control**

*Annual European Control Conference, Lymassol, Cyprus, June 12-15 2018.*

### **Family-Personalized Dietary Planning with Temporal Dynamics**

*Annual American Control Conference, Milwaukee, USA, June 27-29, 2018.*

### **Dynamic Watermarking for General LTI Systems**

*56th IEEE Conference on Decision and Control, Melbourne, Australia, December 12-15, 2017.*

### **Deterministic Approximation Algorithm For Population-Scale Personal Dietary Management**

*INFORMS Computing Society Conference, Austin, TX, 2017.*

### **Deterministic Approximation Algorithms For Population-scale Personal Dietary Management**

*INFORMS Annual Meeting, Nashville, TN, 2016.*

## **HONORS AND AWARDS**

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**Marshall-Oliver-Rosenberger Fellowship Award** - granted by the Industrial Engineering and Operations Research Department at University of California Berkeley

**Outstanding GSI Awards** - granted by the Industrial Engineering and Operations Research Department at University of California Berkeley

**Outstanding Graduate Student Instructor 2019** - granted by the Graduate Division of University of California Berkeley

**ENGIE Brazil Innovation Prize** - granted by ENGIE Group for the development of the HERA software.

**PUC's Academic Performance Premium** - granted by Pontifical Catholic University of Rio de Janeiro to students with the highest GPA.

**Medal Graça Couto** - granted by the Military School of Rio de Janeiro to the student with the highest academic performance of the school.

**Medal Thomaz Coelho** - granted by the Military School of Rio de Janeiro to the student with the highest GPU during all years during highschool.

## **TECHNICAL SKILLS**

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### **Computer Languages**

C/C++ , Python, R, Matlab

### **Mathematical Programming**

Xpress, Gurobi, CPLEX, GAMS, AMPL

### **Machine Learning and Big Data**

TensorFlow, Pandas, Keras

### **Software and Algorithm Development**

### **Statistical and Risk Analysis**

### **Soft skills**

Communicative. Proactive leader. Problem-solver

### **Languages**

English, Portuguese, Spanish

### **Others**

VBA, @Risk, Eviews, MS Office

## **VOLUNTEER WORK**

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**Associação Paulo Cesar** - Worked with a group of students to recover and repair computers for children in the community of Morro do Adeus in Rio de Janeiro, Brazil.