

María Santos

POSTDOCTORAL RESEARCHER · PRINCETON UNIVERSITY

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multi-agent systems · decentralized decision making · optimization · networked control · machine learning

Education

Ph.D. in Electrical and Computer Engineering

Aug. 2016 - Jul. 2020

GEORGIA INSTITUTE OF TECHNOLOGY, ATLANTA, GA, USA

GPA: 4.0/4.0

- Dissertation: Coverage control: From heterogeneous robot teams to expressive swarms
- Minor: Computer Science

M.S. in Electrical and Computer Engineering

Aug. 2014 - May 2016

GEORGIA INSTITUTE OF TECHNOLOGY, ATLANTA, GA, USA

GPA: 4.0/4.0

B.S./M.S. Diploma in Engineering, Automation and Electronics

Sep. 2008 - Sep. 2013

UNIVERSIDADE DE VIGO, VIGO, SPAIN

GPA: 8.67/10.0

Professional Degree in Music, Violin

Sep. 2008 - Jun. 2012

CONSERVATORIO DE MÚSICA MANUEL QUIROGA, PONTEVEDRA, SPAIN

GPA: 8.60/10.00

Experience

Princeton University

POSTDOCTORAL RESEARCHER (SUPERVISOR: NAOMI EHRICH LEONARD)

Oct. 2020 - present

- Developed **statistical models** for multi-agent teams **to learn unknown tasks and optimize their execution**. Designed algorithms where the multi-agent task is modeled as Gaussian processes that can be solved in a decentralized way
- Worked on decentralized **decision making** strategies that use **game theory** and **nonlinear opinion dynamics** for multi-agent task allocation and inter-agent coordination. Multi-agent coordination (agreement/disagreement over options) is proved analytically using bifurcation theory
- Deployment of algorithms for multi-robot path planning and decision making (using **Python, MATLAB, ROS**) on robotic platforms (TurtleBot with OpenMANIPULATOR-X, Clearpath Jackal), motion capture system (Vicon)
- **Technical advisor** of 4 graduate students and co-advisor of 7 undergraduate students
- Co-organizer of the ICRA 2023 **Workshop on Multi-Robot Learning**

LECTURER: MODERN CONTROL (MAE 434)

Spring 2022

- Course on state-space methods for robust **control design and analysis of dynamical systems**. Topics included stability analysis (Lyapunov and input-output), controllability, feedback control, state estimation, and optimal and robust control design methods (LQR, MPC)

Georgia Institute of Technology

GRADUATE RESEARCH ASSISTANT (PH.D. ADVISOR: MAGNUS EGERSTEDT)

Aug. 2016 - Jul. 2020

- Designed mathematical models to capture the complexities of **heterogeneous agents** with different equipment/capabilities. Built a **decentralized optimization** method whereby the heterogeneous team fulfills multiple tasks by executing heterogeneous gradient descent strategies
- Developed algorithms for multi-agent teams to **optimize time-varying objectives** in a decentralized fashion. Each agent minimizes its control action solving a quadratic programming problem where tasks are synthesized as constraints
- Designed **human-swarm interaction** strategies to command dynamic objectives to multi-agent teams in real time
- **Technical advisor** of 2 visiting international students and advisor of 1 undergraduate student

GRADUATE TEACHING ASSISTANT AND GUEST LECTURER: OPTIMAL CONTROL AND OPTIMIZATION (ECE 6553)

Spring 2017

- Graduate level course on **optimal control** of dynamic systems, **numerical optimization** techniques and their applications in solving optimal-trajectory problems

GRADUATE TEACHING ASSISTANT: ADVANCED PROGRAMMING TECHNIQUES (ECE 4122/6122)

Fall 2015

- Undergraduate/graduate course on **advanced topics in programming methods**, data management, distributed computing, and advanced algorithms used in typical engineering applications (C & C++)

Universidade de Vigo

RESEARCH ASSISTANT (ADVISOR: JOAQUÍN LÓPEZ FERNÁNDEZ)

Oct. 2012 - Jul. 2014

- Developed libraries for **task allocation and scheduling** (ROS, Java) and obstacle avoidance (C) for a robotics development framework

Publications

JOURNAL PUBLICATIONS

- [J6] A. Bizyaeva, G. Amorim, **M. Santos**, A. Franci and N. E. Leonard, “Switching transformations for decentralized control of opinion patterns in signed networks: application to dynamic task allocation”, *IEEE Control Systems Letters*, June 2022.
- [J5] S. Kim, **M. Santos**, L. Guerrero-Bonilla, A. Yezzi, and M. Egerstedt. “Coverage Control of Mobile Robots With Different Maximum Speeds for Time-Sensitive Applications”, *IEEE Robotics and Automation Letters*, April 2022.
- [J4] **M. Santos**, G. Notomista, S. Mayya, and M. Egerstedt. “Interactive Multi-Robot Painting Through Colored Motion Trails” *Frontiers in Robotics and AI, Robotic Control Systems*, Vol. 7, 143, 2020.
- [J3] **M. Santos** and M. Egerstedt. “From Motions to Emotions: Can the Fundamental Emotions Be Expressed in a Robot Swarm?” *International Journal of Social Robotics*, July 2020.
- [J2] **M. Santos**, Y. Diaz-Mercado and M. Egerstedt, “Coverage Control for Multirobot Teams With Heterogeneous Sensing Capabilities.” *IEEE Robotics and Automation Letters*, vol. 3, no. 2, pp. 919-925, April 2018.
- [J1] J. López, D. Pérez, **M. Santos** and M. Cacho. “GuideBot. A Tour Guide System Based on Mobile Robots.” *International Journal of Advanced Robotic Systems*, 10:381, November 2013.

CONFERENCE PUBLICATIONS

- [C9] K. Nakamura*, **M. Santos***, and N. E. Leonard. “Decentralized Learning With Limited Communications for Multi-robot Coverage of Unknown Spatial Fields”. *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, Kyoto, Japan, Oct. 2022. (*Equal contribution.)
- [C8] **M. Santos**, U. Madhushani, A. Benevento, and N. E. Leonard. “Multi-robot Learning and Coverage of Unknown Spatial Fields”. *IEEE International Symposium on Multi-robot and Multi-agent Systems (MRS)*, Cambridge, UK, Nov. 2021.
- [C7] A. Benevento, **M. Santos**, G. Notarstefano, K. Paynabar, M. Bloch, and M. Egerstedt. “Multi-Robot Coordination for Estimation and Coverage of Unknown Spatial Fields”. *IEEE International Conference on Robotics and Automation (ICRA)*, Paris, May 2020.
- [C6] R. Funada, **M. Santos**, T. Gencho, J. Yamauchi, M. Fujita, and M. Egerstedt. “Visual Coverage Maintenance for Quadcopters Using Nonsmooth Barrier Functions”. *IEEE International Conference on Robotics and Automation (ICRA)*, Paris, May 2020.
- [C5] G. Notomista, S. Mayya, M. Selvaggio, **M. Santos**, and C. Secchi. “A set-theoretic approach to multi-task execution and prioritization”. *IEEE International Conference on Robotics and Automation (ICRA)*, Paris, May 2020.
- [C4] **M. Santos**, S. Mayya, G. Notomista, and M. Egerstedt. “Decentralized Minimum Energy Coverage Control for Time-Varying Density Functions”. *IEEE International Symposium on Multi-robot and Multi-agent Systems (MRS)*, Aug. 2019. **Outstanding paper finalist.**
- [C3] G. Notomista, **M. Santos**, S. Hutchinson, and M. Egerstedt. “Sensor Coverage Control Using Robots Constrained to a Curve”. *IEEE International Conference on Robotics and Automation (ICRA)*, Montreal, May 2019.
- [C2] R. Funada, **M. Santos**, J. Yamauchi, T. Hatanaka, M. Fujita, and M. Egerstedt. “Visual Coverage Control for Teams of Quadcopters via Control Barrier Functions”. *IEEE International Conference on Robotics and Automation (ICRA)*, Montreal, May 2019.
- [C1] **M. Santos** and M. Egerstedt. “Coverage Control for Multi-Robot Teams with Heterogeneous Sensing Capabilities Using Limited Communications”. in *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, Madrid, Oct. 2018.

WORKSHOP PAPERS

- [W2] **M. Santos**, U. Madhushani, A. Benevento, and N. E. Leonard. “Multi-robot Learning and Coverage of Unknown Spatial Fields”. *ARMS-2022: AAMAS Workshop on Autonomous Robots and Multi-Robot Systems*, Auckland, New Zealand, May 2022.
- [W1] **M. Santos** and M. Egerstedt. “From Motions to Emotions: Exploring the Emotional Expressiveness of Robot Swarms”. *ICRA-X: Robotic Art Program*, Montréal, May 2019.

Skills

Programming Python (numpy, scipy, cvxpy, scikit-learn, pandas, gpytorch), MATLAB, C++, ROS, Java

Relevant Coursework Linear Systems and Controls, Nonlinear Systems, Optimal Control, Networked Control, Stochastic Systems, Random Processes, Machine Learning, Statistical Machine Learning, Machine Learning for Trading, Advanced Programming Techniques

Scholarships & Awards

La Caixa Scholarship for Graduate Studies in North-America

Aug. 2017 - Aug. 2019

Fulbright Scholarship for Graduate Studies

Aug. 2014 - May 2016

Outstanding Graduate of the Year 2013-2014, awarded by Xunta de Galicia

Oct. 2015

Outstanding Graduate of the Year 2013-2014, awarded by Universidade de Vigo

Jan. 2015