

María Santos

POSTDOCTORAL RESEARCHER · SWARM ROBOTICS

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Research Interests

Heterogeneous Swarms Control of multi-robot teams with diverse capabilities in multi-objective applications

Multi-Robot Learning Distributed estimation and learning for multi-robot exploration

Human-Swarm Interaction for Robotic Art Design of expressive motions for deployment of swarms in artistic exhibitions
High-level strategies to enable humans to control swarms with applications to robotic painting

Education

Georgia Institute of Technology

Atlanta, GA, USA

PHD IN ELECTRICAL AND COMPUTER ENGINEERING

Aug. 2016 - Jul. 2020

- Thesis: *Coverage Control: From Heterogeneous Robot Teams to Expressive Swarms*
- Cumulative GPA: 4.0/4.0

MASTER OF SCIENCE IN ELECTRICAL AND COMPUTER ENGINEERING

Aug. 2014 - May 2016

- Thesis: *Musical Abstractions for Multi-Robot Coordination*
- Cumulative GPA: 4.0/4.0

Universidade de Vigo

Vigo, Spain

MASTER IN ADVANCED INDUSTRIAL PROCESSES AND TECHNOLOGIES

Oct. 2013 - Jul. 2014

- Thesis: *Obstacle Avoidance System in 3D Based on CVM*
- Cumulative GPA: 9.18/10.00

INDUSTRIAL ENGINEERING, SPECIALIZATION IN AUTOMATIC CONTROL AND ELECTRONICS

Sep. 2008 - Sept. 2013

- Thesis: *Adaptation of RIDE Environment Tools to the ROS Architecture*
- 5 year engineering degree equivalent to BSc and MSc
- Cumulative GPA: 8.67/10.00 (*Most Outstanding Graduate Award*)

Conservatorio de Música Manuel Quiroga

Pontevedra, Spain

PROFESSIONAL DEGREE IN MUSIC, SPECIALIZATION IN VIOLIN

Sep. 2005 - Jun. 2012

- Cumulative GPA: 8.60/10.00

Professional Appointments

Princeton University

Department of Mechanical and Aerospace Engineering

Princeton, NJ, USA

POSTDOCTORAL RESEARCH ASSOCIATE

Oct. 2020 - present

- Leonard Lab
- Principal Investigator: Dr. Naomi Leonard
- Research areas: distributed decision making, heterogeneous multi-agent teams, engineering and the arts

Georgia Institute of Technology

School of Electrical and Computer Engineering

Atlanta, GA, USA

GRADUATE RESEARCH ASSISTANT

Aug. 2016 - present

MASTER'S STUDENT

Jan. 2015 - May 2016

- GRITS Lab
- Advisor: Dr. Magnus Egerstedt
- Research areas: control theory, swarm robotics, human-swarm interaction, robots and arts

Universidade de Vigo
Department of Automatic Control and Systems Engineering

GRADUATE RESEARCH ASSISTANT

UNDERGRADUATE RESEARCH ASSISTANT

- Group of Robotics and Intelligent Systems
- Advisor: Dr. Joaquín López Fernández
- Research areas: robotic control architecture, executive layer, obstacle avoidance

Vigo, Spain

Oct. 2013 - Jul. 2014

Oct. 2012 - Jul. 2013

Teaching Experience

Teaching Staff

Coursera

CONTROL OF MOBILE ROBOTS

Feb. 2019 - Aug. 2020

- MOOC on the application of modern control theory to control mobile robots
- Responsibilities: updating course materials, moderating discussion forums

Graduate Teaching Assistant & Co-Instructor

Georgia Institute of Technology

OPTIMAL CONTROL AND OPTIMIZATION, ECE 6553

Spring 2017

- Graduate course on optimal control of dynamic systems, numerical optimization techniques and their applications in solving optimal-trajectory problems
- Responsibilities: lecturing, holding office hours, co-designing homework, grading (97 on-campus students and 25 off-campus)

Graduate Teaching Assistant

Georgia Institute of Technology

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++)
- Responsibilities: holding office hours, grading (200 on-campus students)

Publications

JOURNAL ARTICLES

- [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 PAPERS

- [C8] **M. Santos**, U. Madhushani, A. Benevento, and N. E. Leonard. "Multi-robot Learning and Coverage of Unknown Spatial Fields". *2021 IEEE International Symposium on Multi-robot and Multi-agent Systems (MRS)*, Cambridge, UK, November 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". *2020 IEEE International Conference on Robotics and Automation (ICRA)*, Paris, France, May 2020, pp. 7740-7746.
- [C6] R. Funada, **M. Santos**, T. Gencho, J. Yamauchi, M. Fujita, and M. Egerstedt. "Visual Coverage Maintenance for Quadcopters Using Nonsmooth Barrier Functions". *2020 IEEE International Conference on Robotics and Automation (ICRA)*, Paris, France, May 2020, pp. 3255-3261.
- [C5] G. Notomista, S. Mayya, M. Selvaggio, **M. Santos**, and C. Secchi. "A set-theoretic approach to multi-task execution and prioritization". *2020 IEEE International Conference on Robotics and Automation (ICRA)*, Paris, France, May 2020, pp. 9873-9879.

- [C4] **M. Santos**, S. Mayya, G. Notomista, and M. Egerstedt. “Decentralized Minimum Energy Coverage Control for Time-Varying Density Functions”. *2019 IEEE International Symposium on Multi-robot and Multi-agent Systems (MRS)*, New Brunswick, NJ, August 2019. **Outstanding paper finalist.**
- [C3] G. Notomista, **M. Santos**, S. Hutchinson, and M. Egerstedt. “Sensor Coverage Control Using Robots Constrained to a Curve”. *2019 IEEE International Conference on Robotics and Automation (ICRA)*, Montreal, May 2019, pp. 3010-3016.
- [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”. *2019 IEEE International Conference on Robotics and Automation (ICRA)*, Montreal, May 2019, pp. 3010-3016.
- [C1] **M. Santos** and M. Egerstedt. “Coverage Control for Multi-Robot Teams with Heterogeneous Sensing Capabilities Using Limited Communications”. in *2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, Madrid, October 2018, pp. 5313-5319.

WORKSHOPS

- [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.

THESES

- [T4] **M. T. Santos Fernández**. *Coverage Control: From Heterogeneous Robot Teams to Expressive Swarms*. PhD Thesis, School of Electrical and Computer Engineering, Georgia Institute of Technology, July 2020.
- [T3] **M. T. Santos Fernández**. *Musical Abstractions for Multi-Robot Coordination*. Master’s Thesis, School of Electrical and Computer Engineering, Georgia Institute of Technology, Apr. 2016.
- [T2] **M. T. Santos Fernández**. *Sistema de Evitación de Obstáculos en 3D Basado en CVM. (3D Obstacle Avoidance System Based on CVM.)*. Master’s Thesis, School of Industrial Engineering, University of Vigo, July 2014.
- [T1] **M. T. Santos Fernández**. *Adaptación de Herramientas del Entorno RIDE para su Utilización en la Arquitectura ROS. (Adaptation of RIDE Environment Tools to the ROS Architecture.)* Proyecto Final de Carrera (Final Engineering Degree Project), School of Industrial Engineering, University of Vigo, Sep. 2013.

Presentations

INVITED TALKS AND SEMINARS

Robotic Swarms: From Heterogeneity to Artistic Expression

FSU-FAMU COLLEGE OF ENGINEERING

Department of Mechanical Engineering Seminar Series

Tallahassee, FL, USA

November 2020

Coverage Control: From Heterogeneous Robot Teams to Expressive Swarms

UNIVERSITY OF PENNSYLVANIA

Multi-Robot Systems Group at GRASP Lab

Philadelphia, PA, USA

September 2019

Coverage Control for Multi-Robot Teams with Heterogeneous Sensing Capabilities Using Limited Communications

GEORGIA INSTITUTE OF TECHNOLOGY

Robotics Student Seminar Series

Atlanta, GA, USA

September 2018

Coverage Control for Multi-Robot Teams with Heterogeneous Sensing Capabilities

GEORGIA INSTITUTE OF TECHNOLOGY

Decision and Control Laboratory Student Symposium

Atlanta, GA, USA

March 2018

CONFERENCE PRESENTATIONS

International Symposium on Multi-robot and Multi-agent Systems (MRS 2019)

TALK

“Decentralized Minimum Energy Coverage Control for Time-Varying Density Functions”

New Brunswick, NJ, USA

August 2019

ICRA-X: Robots and Art Program - Expressive Motions (ICRA 2019)

Montréal, Canada

SPOTLIGHT TALK AND POSTER PRESENTATION

May 2019

"From Motions to Emotions: Exploring the Emotional Expressiveness of Robot Swarms"

International Conference on Intelligent Robots and Systems (IROS 2018)

Madrid, Spain

SPOTLIGHT TALK AND INTERACTIVE PRESENTATION

October 2018

"Coverage Control for Multi-Robot Teams with Heterogeneous Sensing Capabilities Using Limited Communications"

International Conference on Robotics and Automation (ICRA 2018)

Brisbane, Australia

POSTER PRESENTATION

May 2018

"Coverage Control for Multi-Robot Teams with Heterogeneous Sensing Capabilities"

Scholarships & Awards

Aug. 2017 - **La Caixa Scholarship for Graduate Studies in North-America**

Aug. 2019 Awarded by Obra Social La Caixa

Oct. 2015 **Premio Fin de Carrera, Xunta de Galicia**

Awarded to the most outstanding Industrial Engineer graduating in the academic year 2013-14 in Galicia, Spain

Jan. 2015 **Premio Fin de Carrera, Universidade de Vigo**

Awarded to the most outstanding Industrial Engineer graduating in 2013-14 at the University of Vigo

Aug. 2014 - **Fulbright Scholarship for Graduate Studies**

May 2016 Awarded by the Fulbright Commission in Spain

Professional Service

Organizer

2021 AMERICAN CONTROL CONFERENCE SPECIAL SESSION

Diversity and Mentorship

Reviewer

IEEE ROBOTICS AND AUTOMATION SOCIETY (RAS)

Transactions on Robotics (T-RO), Robotics and Automation Letters (RA-L), International Conference on Robotics and Automation (ICRA), International Conference on Intelligent Robots and Systems (IROS), International Symposium on Multi-Robot and Multi-Agent Systems (MRS)

SPRINGER

Autonomous Robots

IEEE CONTROL SYSTEMS SOCIETY (CSS)

Transactions on Automatic Control (TAC), Transactions on Control of Network Systems (TCNS), Control Systems Letters (L-CSS)

Media Coverage

[M7] **TECHnically Creative with María Santos**, *TECHnically Creative: Georgia Tech Alumni and the Arts*, Facebook Live interview, January 2021.

[M6] **Robot swarms guided by human artists could paint colourful pictures**, *New Scientist*, October 2020.

Tiny robots create art and other tech news stories, *BBC News*.

Researchers train robot swarm to serve as 'real-life paintbrushes', *ZME Science*.

In the near future, robot swarms guided by human artists could execute paintings, *Designboom*.

Robots might take over this essential human form of expression, *Inverse*.

Robot swarms follow instructions to create art, *TechXplore, Robohub, Medium, Frontiers Science News, Nanowerk News*.

Tiny robots work together to paint pictures, *New Atlas*.

Scientists program robot swarms to create art, *UPI*.

New system helps control swarm of robots to paint a picture, *AZoRobotics*.

Roboter-Schwarm als Pinsel-Ersatz in der Kunst (Robot Swarm as a Replacement for Brushes in Art), *Heise Online*.

Ein Roboterschwarm wird kreativ (A robotic swarm gets creative), *Scinexx - Das Wissensmagazin*.

Desarrollan enjambres de robots que podrán pintar cuadros a partir de música (Researchers develop robotic swarms which will be able to render paintings from music), *La Voz de Galicia*.

Sciame di robot diventano pittori (Swarms of robots become painters), *Agenzia Nazionale Stampa Associata (ANSA)*.

Sciame di robot guidati da artisti umani per creare composizioni pittoriche (Robotic swarms led by human artists to create pictorial compositions), *Affari Italiani*.

[M5] **From motion to emotion: The potential of robot swarms in artistic performances**, *TechXplore*, April 2019.

[M4] **Gallegos en la Cima. María Santos Fernández: "EEUU te anima a salir de lo común y me ha permitido fusionar robótica y música"** (Galicians on Top. María Santos Fernández: "USA encourages you to think outside the box and has allowed me to mix robotics and music"), *Faro de Vigo*, March 2018.

[M3] **Santos Chosen for La Caixa Fellowship**, *Georgia Tech News Center*, June 2017.

La violinista que investiga sobre robótica (The violinist that is also a robotics researcher), *La Voz de Galicia*, June 2017.

La caldense María Teresa Santos, becada por "La Caixa" (María Santos receives a "La Caixa" Fellowship), *Faro de Vigo*, June 2017.

Una caldense ampliará estudios en EE.UU. tras lograr una beca "La Caixa" (A woman from Caldas will further her studies in the US after been awarded a "La Caixa" Fellowship), *La Voz de Galicia*, May 2017.

[M2] **Women of Robotics**, *Georgia Tech News Center*, April 2017.

[M1] **Una mente prodigiosa para idear robots en Georgia** (A prodigious mind to conceive robots in Georgia), *La Voz de Galicia*, April 2014.

Outreach

IES Aquis Celenis – International Day of Women and Girls in Science Event

Caldas de Reis, Galicia, Spain

SPEAKER

Feb 2021

Promotion of STEAM disciplines to secondary school students from the perspective of a female researcher.

CEIP Alborada – International Day of Women and Girls in Science Event

A Coruña, Galicia, Spain

SPEAKER

Feb 2021

Promotion of STEAM disciplines to secondary school students from the perspective of a female researcher.

IES Meaño – International Day of Women and Girls in Science Event

Meaño, Galicia, Spain

SPEAKER

Feb 2020

Promotion of STEAM disciplines to secondary school students from the perspective of a female researcher.

Atlanta Girls' School – MAKE Her Day

Atlanta, GA, USA

PANELIST

Apr 2019

Promotion of STEM disciplines to middle school girls from female professionals.

International Mentoring Foundation for the Advancement of Higher Education (IMFAHE)

Spain

MENTOR

Oct 2016 - Jul 2018

Career mentoring for Spanish master's and PhD students