Steven A. P. Quintero

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Education

Ph.D. **University of California, Santa Barbara**, Electrical and Computer Engineering, September 2014.

Dissertation title: Optimal Control and Coordination of Small UAVs for Vision-based Target Tracking.
Committee: João P. Hespanha (chair), Francesco Bullo, Katie Byl, and Michael Ludkovski.

M.S. **University of California, Santa Barbara**, Electrical and Computer Engineering, June 2009.

Major: Control Systems / *Minor:* Signal Processing

B.S. **Embry-Riddle Aeronautical University**, Electrical Engineering, *Summa Cum Laude*, May 2007.

Research Experience

Postdoctoral Researcher, *University of California, Santa Barbara*, September 2014 – Present.

Studied the problem of using multiple continuously rotating quadcopters equipped with directional antennas to perform localization and tracking of a moving radio frequency (RF) source. Employed a particle filter that utilizes a motion model inspired by the tumble and run behavior of bacteria and also directly incorporates the directional received signal strength (RSS) measurements of the radio signal emitted by the RF source, which is made possible by learning the RSS measurement likelihood function offline. Wrote Python scripts and assembled quadcopters to perform live flight experiments that verify the efficacy of the proposed approach, which achieves an average position estimation error on par with that of commodity GPS receivers.

Graduate Student Researcher, *University of California, Santa Barbara*, January 2009 – September 2014.

Studied the problem of visually tracking and estimating the position of a randomly moving ground target with a small, fixed-wing Unmanned Aerial Vehicle (UAV) equipped with a gimbaled camera. Used probabilistic planning techniques to generate control policies that are robust to unpredictable target motion and unmodeled system dynamics while enabling the following autonomous flight behaviors:

1. One UAV with a limited sensing region to maintain visibility and proximity to the ground target
2. Multiple UAVs to flock together in order to distribute the sensing task amongst group members
3. Two UAVs to optimally coordinate in order to gather the best joint vision-based measurements of the ground target's position.

Derived a policy generation technique along with an essential partitioned robust regression scheme to circumvent the computational challenges associated with the dynamic programming solution to the stochastic optimal coordination of two UAVs. Validated control policies through either Monte Carlo simulations or live flight experiments, where the latter was done as a partnership with Toyon Research Corporation, who supplied the UAV and ground control station hardware.

Research Intern, *UCSB* in collaboration with *Toyon Research Corporation*, June 2008 – December 2008.

Performed the cost/benefit analysis of employing different UAV platforms to survey areas of interest using EO/IR sensors. Derived mathematical machinery to account for gimbaled sensors and compute the number of aircraft in a homogeneous fleet required to maximize line-of-sight coverage. Employed proprietary Toyon software to perform line-of-sight analysis.

Undergraduate Student Researcher, *NASA Dryden Flight Research Center, Edwards, CA*, Summer 2007.

Implemented a system to monitor and characterize the current draw behavior of model aircraft servos aboard a small rotary-winged UAV in order to verify the structural integrity of the aircraft servos and linkages. Designed a circuit board that monitors the current draw using sense resistors in conjunction with an embedded microprocessor.

Undergraduate Student Researcher, *NASA Dryden Flight Research Center, Edwards, CA*, Summer 2006.

Designed a global range data acquisition system for the scientific missions of small UAVs. Utilized a PC104 CPU module to acquire sensor data from a custom-designed printed circuit board and communicate over the horizon via an Iridium modem. Implemented the design using Montavista Linux, Embedded C, and OrCAD.

Technical Skills

Optimal control: linear quadratic regulation (LQR), dynamic programming (DP), model predictive control (MPC)

Motion planning and decision-making under uncertainty (advanced techniques):

1. Regression-based DP: A simulation-based policy generation technique for probabilistic planning that utilizes a regression-based prediction of the continuation cost (Q-factor) encountered in the DP solution to discrete-time stochastic optimal control problems.
2. Nonlinear model predictive control (MPC) with moving horizon estimation (MHE): An online optimal control technique that combines nonlinear MPC with MHE into a single min-max optimization, thereby producing a robust, output-feedback approach to MPC.

State estimation: Kalman filtering, unscented Kalman filtering, particle filtering

Supervised learning: robust, nonlinear regression for problems with a moderate number of predictors and large data sets, i.e., problems with $1-10$ predictors and several million measurements.

Programming

1. C++ - Performed value iteration to determine the optimal control policy for a UAV to track a randomly moving ground target. Utilized classes, templates, pointers to functions, valarray containers, and binary file I/O to generate, test, and store the control policy.
2. MATLAB - Utilized software extensively to perform regression-based dynamic programming, MPC with MHE, and Monte Carlo simulations with the use of the distributed computing and parallel computing toolboxes.
3. Embedded C - Programmed embedded microprocessors with the 8051 instruction set to perform data acquisition for undergraduate senior design course and NASA undergraduate student research projects.

Research Interests

1. Robotic motion planning under uncertainty (probabilistic planning)
2. Optimal control and coordination of autonomous vehicles
3. Monte Carlo methods for stochastic optimal control and probabilistic planning
4. Guidance, navigation, and control of small UAVs

Recent Talks and Poster Presentations

Stochastic Optimal Coordination of Small UAVs for Target Tracking using Regression-based Dynamic Programming,
26th Southern California Control Workshop, UCSB, April 11, 2014 (Talk)

Optimal UAV Coordination for Target Tracking using Dynamic Programming,
Santa Barbara Control Workshop, Santa Barbara, CA, June 24, 2011 (Poster)

Aerial Surveillance of a Moving Target with a Small Fixed-Wing UAV,
21st Southern California Control Workshop, UCLA, October 14, 2011 (Talk)

Optimal UAV Coordination for Target Tracking using Dynamic Programming,
19th Southern California Control Workshop, UCSB, October 8, 2010 (Talk)

Publications

Journal Articles

[1] S. A. P. Quintero, M. Ludkovski, J. P. Hespanha. "Stochastic Optimal Coordination of Small UAVs for Target Tracking using Regression-based Dynamic Programming." Note: Submitted.

[2] S. A. P. Quintero and J. P. Hespanha. "Vision-based Target Tracking with a Small UAV: Optimization-based Control Strategies," *Control Engineering Practice*, 32:28–42, Nov. 2014.

Refereed Conferences

[1] S. A. P. Quintero, D. A. Copp, and J. P. Hespanha. "Robust UAV Coordination for Target Tracking using Output-Feedback Model Predictive Control with Moving Horizon Estimation," *Proceedings of the American Control Conference*, Chicago, IL, July 2015. Note: To appear.

[2] S. A. P. Quintero, G. E. Collins, and J. P. Hespanha. "Flocking with Fixed-Wing UAVs for Distributed Sensing: A Stochastic Optimal Control Approach," *Proceedings of the American Control Conference*, Washington, D.C., June 2013.

[3] S. A. P. Quintero, F. Papi, D. J. Klein, L. Chisci, and J. P. Hespanha, "Optimal UAV Coordination for Target Tracking using Dynamic Programming," *Proceedings of the IEEE Conference on Decision and Control*, Atlanta, GA, December 2010.

Honors and Awards

ECE Dissertation Fellowship – Awarded for Spring quarter of 2013-2014 academic year

Best Presentation in Session, American Control Conference, June 2013

ECE Distinguished Graduate Research Fellowship – Awarded for 2007-2008 academic year

McNair Scholars Program – Alumni

Eta Kappa Nu (Electrical Engineering Honors Society) – Member

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Teaching Experience

Mentor, *University of California, Santa Barbara*, Summer 2011 & Summer 2014

ICB High School Robotics Challenge

Mentored four Java-proficient high school students in a rigorous six week summer internship focused on project-based learning. Designed hardware-based computer programming projects to introduce the students to concepts in feedback control, robotics, and software development. Held daily interactions with students to provide them with technical guidance, project management advice, and background information on control systems and robotics topics.

Teaching Assistant, *University of California, Santa Barbara*, 2010

Advanced Control Design Lab, Professor Katie Byl, Spring 2010.

Held office hours in the laboratory for a project-based course designed to introduce students to natural phenomenon and practices encountered in real-world control implementations, including sampling, digital control design, state estimation, and nonlinear dynamics. Guided students in the design and implementation of feedback control projects, such as the swing-up and stabilization of the following mechatronic devices: inverted pendulum on a cart, Furuta pendulum, and pendubot.

Professional Affiliations

Center for Control, Dynamical-Systems, and Computation (CCDC)

Institute for Electrical and Electronics Engineers (IEEE)

IEEE Control Systems Society (IEEE CSS)