Paul Ruvolo

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RESEARCH INTERESTS

Robotics. Machine Learning. Computational analyses of behavior. Artificial Intelligence. Forward and inverse stochastic optimal control. Multi-task and Transfer Learning. Facial expression mimicry and embodied cognition. Machine perception including auditory, visual, and multimodal approaches. High-throughput crowdsourcing for machine perception.

EDUCATION AND ACADEMIC APPOINTMENTS

Olin College of Engineering, Needham, MA USA

Assistant Professor, Engineering, September 2013-Present

Bryn Mawr College, Bryn Mawr, PA USA

Postdoctoral Researcher., Computer Science, July 2012-June 2013

- Research topic: *Lifelong Learning*
- Adviser: Dr. Eric Eaton

Lecturer, Computer Science, September 2012-May 2013

- Co-instructor for two semesters in *Creative Computing* (Introduction to Computer Science)

University of California San Diego, La Jolla, CA USA

Ph.D., Computer Science and Engineering, June 2012

- Thesis Topic: *Computational Approaches to the Analysis and Synthesis of Social Behavior*
- Adviser: Dr. Javier R. Movellan

Lecturer, Computer Science, Summer 2011

- Instructor for *Math for Algorithms and Systems Analysis*

M.S., Computer Science and Engineering, September 2008

Harvey Mudd College, Claremont, CA USA

B.S., Computer Science, May 2003

- Final Project Topic: *Content-based Music Recommendation and Playlist Generation*

PUBLICATIONS

K. Keil, A. Morrow, J.B. Geddes, P. Ruvolo Autonomous sailing for blind sailors using GPS *OCEANS 2017-Aberdeen*, IEEE, 2017.

R. Jordan, A. Morrow, P. Ruvolo Sensing sail luffing by detection of sail shape *OCEANS 2017-Aberdeen*, IEEE, 2017.

D.J. Mir, S. Mishra, P. Ruvolo, L. Pollock, S. Engen How Do Faculty Partner While Teaching Interdisciplinary CS+X Courses: Models and Experiences *Journal of Computing Sciences in Colleges*, 32(6): 24–33, 2017.

P. Ruvolo. Dude, Where's My Robot?: A Localization Challenge for Undergraduate Robotics *Educational Advances in Artificial Intelligence, EAAI*, 2017.

P. Ruvolo, D.M. Messinger, and J.R. Movellan. Infants Time Their Smiles to Make Their Moms Smile *PLOS ONE*, 2015: e0136492.

H. Bou Ammar, E. Eaton, Jose Marcio Luna, and P. Ruvolo. Autonomous Cross-Domain Knowledge Transfer in Lifelong Policy Gradient Reinforcement Learning *Proceedings of the 24th International Joint Conference on Artificial Intelligence*, 2015.

H. Bou Ammar, E. Eaton, P. Ruvolo, and M. Taylor. Unsupervised Cross-Domain Transfer in Policy Gradient Reinforcement Learning via Manifold Alignment *Proceedings of the Twenty-Ninth AAAI Conference on Artificial Intelligence*, 2015.

G. Hofree, P. Ruvolo, M. Bartlett, and P. Winkielman. The Android in the Room: Spontaneous Mimicry of a Physically Present Android. *PLOS ONE*, 2015: e99934.

H. Bou Ammar, E. Eaton, P. Ruvolo, and M.E. Taylor. Online Multi-Task Learning for Policy Gradient Methods. *International Conference on Machine Learning*, 2014.

P. Ruvolo and E. Eaton. Online Multi-Task Learning via Sparse Dictionary Optimization. *Proceedings of the Twenty-Eighth AAAI Conference on Artificial Intelligence*, 2014.

D. Messinger, L. Duvivier, Z. Warren, M. Mahoor, J. Baker, A. Warlaumont, P. Ruvolo Affective Computing, Emotional Development, and Autism. *Handbook of Affective Computing*, Oxford Press, New York, 2014.

P. Ruvolo, J. Whitehill, and J.R. Movellan. Exploiting structure in crowdsourcing tasks using latent factor models. *Neural Information Processing Systems Workshop on Crowdsourcing: Theory, Algorithms and Applications*, 2013.

P. Ruvolo and E. Eaton. Active Task Selection for Lifelong Machine Learning. *Proceedings of the Twenty-Seventh AAAI Conference on Artificial Intelligence*, 2013.

P. Ruvolo and E. Eaton. ELLA: An efficient lifelong learning algorithm. *International Conference on Machine Learning*, 2013.

P. Ruvolo and E. Eaton. Online Multitask Learning based on K-SVD. *International Conference on Machine Learning, Workshop on Theoretically Grounded Transfer Learning*, 2013.

P. Ruvolo and E. Eaton. Scalable lifelong learning with active task selection. *AAAI Spring Symposium on Lifelong Learning*, 2013.

G. Hofree, P. Ruvolo, C. Reinert, M. Bartlett, and P. Winkielman. Why are you smiling? In a strategic context, people's affective responses reflect the meaning of android's facial expressions. *IEEE International Conference on Development and Learning and Epigenetic Robotics (ICDL)*, 2012.

P. Ruvolo A Computational Approach to the Study of Social Interaction. *UC San Diego Doctoral Dissertation*, 2012.

P. Ruvolo, T. Wu, and J. Movellan. Control by gradient collocation: Applications to optimal obstacle avoidance and minimum torque control. *Intelligent Robots and Systems (IROS)*, 2012.

T. Wu, N. Butko, P. Ruvolo, J. Whitehill, M. Bartlett, and J. Movellan. Multi-layer architectures for facial action unit recognition. *IEEE Transactions on System, Man, and Cybernetics*, 2012.

J. Artigas, W. Mattson, D. Messinger, P. Ruvolo, T. Wu, and J. Movellan. Rethinking motor development and learning. *Proceedings of IEEE International Conference on Development and Learning*, 2011.

G. Littlewort, M. Bartlett, J. Whitehill, T. Wu, N. Butko, P. Ruvolo, and J. Movellan. The motion in emotion – a cert baed approach to the fera emotion challenge. *Proceedings of FERA Workshop at Face and Gesture*, 2011.

D.M. Messinger, N.V. Ekas, P. Ruvolo, and A.D. Fogel. are you interested, baby? young infants exhibit stable patterns of attention during interaction. *Infancy*, 2011.

T. Wu, W. Mattson, J. Artigas, P. Ruvolo, J. Movellan, and D. Messinger. Collecting a developmental dataset of reaching behavior: First steps. *IROS Workshop on Cognitive Neuroscience Robots*, 2011.

T. Wu, N. Butko, P. Ruvolo, J. Whitehill, M. Bartlett, and J. Movellan. Between-dataset au recognition transfer. *Proceedings of FERA Workshop at Face and Gesture*, 2011.

H. Finger, S.C. Liu, P. Ruvolo, and J.R. Movellan. Approaches and databases for online calibration of binaural sound localization for robotic heads. In *Intelligent Robots and Systems (IROS), 2010 IEEE/RSJ International Conference on*, pages 4340–4345. IEEE, 2010.

D.M. Messinger, P. Ruvolo, N.V. Ekas, and A. Fogel. Applying machine learning to infant interaction: The development is in the details. *Neural Networks*, 23(8-9):1004–1016, 2010.

P. Ruvolo, I. Fasel, and J.R. Movellan. A learning approach to hierarchical feature selection and aggregation for audio classification. *Pattern Recognition Letters*, 2010.

P. Ruvolo, J. Whitehill, and J.R. Movellan. Exploiting structure in crowdsourcing tasks via latent factor models. Technical report, Technical Report TR2010. 01, Machine Perception Laboratory, 2010.

P. Ruvolo and J.R. Movellan. An alternative to low-level-synchrony-based methods for speech detection. *Advances in Neural Information Processing Systems*, 2010.

I. Fasel, P. Ruvolo, T. Wu, and J. Movellan. Infomax control for social robots. In *NIPS Workshop on Probabilistic Approaches for Robotics and Control*, 2009.

P. Ruvolo, I. Fasel, and J. Movellan. Optimization on a budget: A reinforcement learning approach. *Advances in Neural Information Processing Systems*, 2009.

P. Ruvolo, I. Fasel, and J. Movellan. Tuning optimizers for time-constrained problems using reinforcement learning. *Proceedings of the Workshop on Optimization for Machine Learning Neural Information Processing Systems*, 2009.

J. Whitehill, P. Ruvolo, T. Wu, J. Bergsma, and J. Movellan. Whose vote should count more: Optimal integration of labels from labelers of unknown expertise. *Advances in Neural Information Processing Systems*, 22:2035–2043, 2009.

T. Wu, N.J. Butko, P. Ruvolo, M.S. Bartlett, and J.R. Movellan. Learning to make facial expressions. *Proceedings of IEEE International Conference on Development and Learning*, 2009.

P. Ruvolo, J. Whitehill, and J. Movellan. Building a more effective teaching robot via apprenticeship learning. In *Proceedings of IEEE International Conference on Development and Learning*, 2008.

P. Ruvolo, I. Fasel, and J. Movellan. Auditory mood detection for social and educational robots. In *Robotics and Automation, 2008. ICRA 2008. IEEE International Conference on*, pages 3551–3556. IEEE, 2008.

P. Ruvolo and J Movellan. Auditory cry detection in early childhood education settings. In *Proceedings of IEEE International Conference on Development and Learning*, 2008.

J.R. Movellan, F. Tanaka, I.R. Fasel, C. Taylor, P. Ruvolo, and M. Eckhardt. The rubi project: a progress report. In *Proceedings of the ACM/IEEE international conference on Human-robot interaction*, pages 333–339. ACM, 2007.

FUNDING   Grants and Contracts

Paul Ruvolo (PI) *Co-Designing Assistive Apps with Students Who Are Blind.* The Peabody Foundation. Budget: $46,000.

Zach Dodds (PI) (Paul Ruvolo (Consultant)) *CS for Insight: Disciplinary Computing Beyond CS1.* NSF. Ruvolo budget total: $20,000.

Paul Ruvolo (PI), Darakhshan Mir (PI), Lori Pollock (PI), and Sumita Mishra (PI). *Collaborative Research: Exploring Partnered Teaching of Interdisciplinary CS+X Courses.* NSF. Olin budget total: $65,177.

Eric Eaton (PI), Matt Taylor (PI), and Paul Ruvolo (PI). *Lifelong Transfer Learning for Heterogeneous Teams of Agents in Sequential Decision Processes.* Air Force Research Lab. Duration February 2014 - February 2016. Olin Subcontract total: $75,000.

Eric Eaton (PI) and Paul Ruvolo (Co-PI). *Interactive Transfer for Continual Lifelong Learning.* Office of Naval Research, Grant #N00014-11-1-0139. Duration September 2014 - September 2015. Olin Budget: $38,732.

PRODUCTS   Smartphone Apps

Clew v1.0.1: (http://clewapp.org) a smartphone app to support indoor navigation for people who are blind or visually-impaired. Creators: Paul Ruvolo, Chris Yoon, Jeremy Ryan, Ryan Louie, Simran Malhi, William Derksen.

CONSULTING   NSF Science of Information Center (http://soihub.org)

Worked on developing educational materials for teaching courses on the science of information and data science.
Insper (http://www.insper.edu.br/en/)

With two Insper faculty, worked to transplant the Olin College "A Computational Introduction to Robotics" course to Insper.
Gettysburg College

Worked with Todd Neller at Gettysburg College to help disseminate course materials from "A Computational Introduction to Robotics" in the Gettysburg curriculum.

PROFESSIONAL
SERVICE   Reviewing (journals)

- Transactions on Autonomous Mental Development (TAMD)
- ACM Transactions on Intelligent Systems and Technology (TIST)
- Journal of Autism and Developmental Disorders (JADD)

Reviewing (conferences)

- AAAI Conference on Artificial Intelligence (AAAI), 2013-2017
- IEEE International Conference on Development and Learning (ICDL), 2011-2012
- Advances in Neural Information Processing Systems (NIPS), 2013-2015

- International Joint Conferences on Artificial Intelligence (IJCAI), 2013-2014
- IEEE Face and Gesture (FG), 2011

Reviewing (funding agencies)

- NSF IUSE (2016)
- Swedish Science Foundation

Program Committee and Reviewer (conferences)

- Conference on Uncertainty in Artificial Intelligence (UAI), 2013
- AAAI Spring Symposia, 2013
- Educational Advances in Artificial Intelligence (EAAI), 2013-2016

Workshops Organized

- Summer Institute Workshop on Quantitative Engineering Analysis, 2017.
- Davis Faculty Development Workshop on Quantitative Engineering Analysis, 2017.
- EAAI (Educational Advances in Artificial Intelligence) co-organizer of special session on hands-on robotics.
- NSF Funded CS+X Workshop in Exploring Co-taught Interdisciplinary Computer Science Courses.
- A Practical Guide to Machine Learning. Presented at the NSF iSLC Conference, 2008.

Invited Talks

- NextML
- MIT Media Lab Personal Robotics Group, October 2013.
- Google Cambridge, Knowledge Graph Research Group, September 2013.
- Keynote address at AAAI Fall Symposium on Robots Learning from Demonstration, 2012.
- Keynote address at AAAI Spring Symposium on Lifelong Machine Learning, 2013.

AWARDS National Academy of Engineering
- Selected for participation in FOEE (Frontiers of Engineering Education Symposium), Irvine, CA. October, 2014.

National Science Foundation
- IGERT Trainee Fellowship, 2005–2007

Harvey Mudd College
- Harvey S. Mudd Merit Scholarship, 1999–2003
- Graduate with Highest Honors, 2003

National Merit Scholarship, 1999

TEACHING
EXPERIENCE **Olin College of Engineering** Needham, MA USA

Assistant Professor of Computer Science, September 2013 - Present

- Quantitative Engineering Analysis II (Fall 2017)
- Quantitative Engineering Analysis I (Spring 2017)
- Data Science (Spring 2014, Spring 2015, Spring 2016)
- A Computational Introduction to Robotics (Fall 2014, Fall 2015, Spring 2017)
- Software Design (Spring 2014, Spring 2015, Spring 2016)
- SCOPE (Senior Capstone Program in Engineering) (2013-2016)
- Modeling and Simulation of the Physical World (Fall 2013)

Bryn Mawr College, Bryn Mawr, PA USA

Lecturer, Computer Science, September 2012-May 2013

- Co-instructor for *Creative Computing* (Introduction to Computer Science) (Fall 2012, Spring 2013)

University of California San Diego, La Jolla, CA USA

Teaching Assistant   **Spring 2011: Math for Algorithms and Systems Analysis** (student evaluations available upon request)

Instructor   **Summer 2011: Math for Algorithms and Systems Analysis**

MENTORSHIP AND OUTREACH

College and University

Michael Bocamazo, Subhash Gubba, Ryan Louie, Lindsey Vanderlyn, and Emily Wang Piloted, launched, and refined Do-ML (Do Machine Learning). This is a student lead group that focuses on both learning about and doing projects on machine learning. Last semester, we ran the sixth iteration of this group.

Emily Wang[1] Sophia Seitz, Lindsey Vanderlyn, Matt Ruehle[2], Christopher Lee, Aditi Joshi, Siddharth Singal, Heather Dudley, Dhasharath Shrivathsa, Anders Johnson[2], Pinar Demetci[2]   Advised a research project (Spring 2014 - Ongoing) on using computer vision and mobile technologies to increase the autonomy of the blind. 1. student presented work at the Grace Hopper conference. 2. students presented work at the Closing the Gap Conference.

Gabrielle Ewall   Advised a research project on computational modeling of recency and primacy effects in working memory.

Zhecan Wang, Joseph Maalouf, and Sean Carter   Supervised a summer research project on lifelong machine learning methods for convolutional neural networks.

Michael Bocamazo, Subhash Gubba, and Deniz Celik   Supervised a summer research project on fault-tolerant control using machine learning.

Heather Boortz   Advised an OSS on evaluating approaches to simultaneous localization and mapping on a Turtlebot2.

Patrick Varin and Arjun Aletty   Advised a research project on machine learning approaches to election forecasting.

Jessica Bethune   Worked on an independent study on both machine learning content as well as pedagogical strategies to teach machine learning to Olin students.

Alec Radford   Helped Alec plan experiments and interpret results for a technique for regularizing the training of Neural Networks based on injection of noise into principal components space.

Megan O'Rourke   Provided computational tools, analysis techniques, and writing assistance on a project to test the link between facial expression mimicry and deception detection accuracy.

Chris M. Reiner   Supervised a summer research fellowship to study what facial expressions people made when playing a game either collaboratively or competitively with a humanoid robot that made eerily realistic facial expressions (paper in preparation).

Quentin Quarles   Supervised on two projects related to human robot interaction and automatic analysis of facial expression mimicry using a computer vision.

Meagan Neal and Jacy Li   Co-advised a summer research project on building and evaluating algorithms for lifelong multi-task learning.

David Wilikofsky   Co-advised a summer research project on human agent transfer in a robot soccer-like domain.

Holger Finger   Provided guidance on the investigation of machine learning methods to localize sounds on a robotic head (paper published at a leading robotics conference: Intelligent Robots and Systems 2010).

K-12

Preuss School FIRST Robotics Club Mentor (2005-2006)   Provided guidance on programming activities for the FIRST robotics competiton.

Reach for Tomorrow Program (2006-2011)   Developed and carried out activities related to machine perception and robotics for the reach for tomorrow program (a program to help at risk junior high and high school students become excited about possible careers in mathematics and science).

San Diego Science Festival (2009)   Developed and carried out activities related to machine perception and robotics for the San Diego Science Festival.

Bullis School, Los Altos, CA USA   Developed a presentation and series of demos to help excite elementary school kids (2nd and 4th grade) about robotics research.

PROFESSIONAL EXPERIENCE

Invio Software, Los Altos, CA USA

Software Developer   **Summer 2001, Summer 2002, September 2003-May 2005**

- Designed and implemented graphical tools for facilitating the automation of key aspects of the management of networked storage devices and applications.
- Contributed to the development of core product functionality for the process automation engine.

BEA Systems, San Jose, CA USA

Web Development Intern   **Summer 2000, December 2000**

- Designed and implemented an early wiki-like tool for creating pages on BEA's intranet without having to write HTML.
- Designed and implemented calendaring and report generating software for internal company use.

PROGRAMMING SKILLS

C, C++, Java, Python, Perl, PHP, UNIX shell scripting, GNU make, MATLAB

EXPERTISE

Mathematics:
- Bayesian statistics, graphical models, convex and nonconvex optimization, discriminative learning (e.g. SVMs and boosting), learning theory, lifelong learning

Control Theory and Engineering:
- Linear and nonlinear systems theory, non-linear filtering, feedback (both discrete and continuous) stochastic optimal control

Machine Perception:
- Image and audio filtering, auditory category recognition, face processing, multimodal learning, facial expression recognition, sound source localization

Computer Science and Engineering:
- Theory of computation, programming languages, computer architecture, operating systems, bioinformatics, complexity theory

Behavioral Sciences:
- Early development of nonverbal behavior in infancy, embodied cognition (simulation theory and facial expression mimicry), human robot interaction, computational modeling of natural systems