Jonathan C. Balloch

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CURRICULUM VITAE

RESEARCH INTERESTS

Interested in developing techniques and algorithms so that intelligent agents and robots to learn continually from visual inputs in the context of the environment. Core focus: is using deep learning and other computer vision techniques that enable robot learning without forgetting and learning from interacting with objects and environments. Experience and areas of interest:

> Reinforcement learning, imitation learning, continual learning, deep learning, computer vision, few-shot learning, semantic segmentation, active learning, learning from demonstration, human-robot interaction, visual affordance learning, visual SLAM, geometry-based reasoning, object detection, and object discovery.

EDUCATION

Doctor of Philosophy (in progress) – **Georgia Institute of Technology**, Atlanta, GA 2016-Present

- Major: Robotics
  - Core areas: Reinforcement Learning, Machine Learning Computer Vision, Artificial Intelligence, Human Robot Interaction
  - Minor: Managing Technology Commercialization
- Advisors: Dr. Mark Reidl, Dr. Irfan Essa, Dr. Sonia Chernova

Masters of Science – **University of Pennsylvania**, Philadelphia, PA 2011-2013

- Major: Robotics
- Advisor: Dr. Kostas Daniilidis

Bachelors of Science – **Georgetown University**, Washington, D.C. 2007-2011

- Majors: Physics, Mathematics

REFEREED PUBLICATIONS

1. Banerjee, S., Daruna, A., Kent, D., Liu, W., Balloch, J. C., Jain, A., Krishnan, A., Chernova, S., "Taking Recoveries to Task: Recovery-Driven Development for Recipe-based Robot Tasks." *IEEE International Symposium on Robotics Research*, 2019.
2. Nair, Lakshmi, **Balloch, J. C.**, Chernova, S. "The MacGyverbot: Tool Construction by Autonomous Agents." *IEEE International Conference on Robotics and Automation*, 2019.
3. **Balloch, J. C.**, Chernova, S. "An RGBD segmentation model for robot vision learned from synthetic data." *Robotics Science and Systems (RSS): Workshop on Spatial-Semantic Representations in Robotics*, 2017.

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4. Endo, Y., **Balloch, J.**, Grushin, A., Lee, M.W., Handelman, D. "Landmark-Based Robust Navigation for Tactical UGV Control in GPS-Denied Communication-Degraded Environments." *SPIE Unmanned Systems Technology XVIII*, 2016.
5. West, R. A., Ovanessian, A., Turtle, E. P., Ray, T., **Balloch, J.**, Dumont, P., Lavvas, P., Lorenz, R., Rannou, P. "Titan's Detached Haze and Polar Vortex: Large-Amplitude Seasonal Variations." *Lunar and Planetary Science Conference*, *43*, 2012.
6. West, R. A., **Balloch, J.**, Dumont, P., Lavvas, P., Lorenz, R., Rannou, P., Turtle, E. P., Ray, T. "The Evolution of Titan's detached haze layer near equinox in 2009." *Geophysical Research Letters*, *38*, doi: 10.1029/2011GL046843, 2011.

OTHER PUBLICATIONS

1. **Balloch, J. C.**, Aggraval, V., Essa, I., Chernova, S. "Unbiasing Semantic Segmentation for Robot Perception using Synthetic Data Feature Transfer." *arXiv:1809.03676*, 2018.

PROFESSIONAL RESEARCH EXPERIENCE

Graduate SWE Intern – Google, 2018

- Worked with the Mobile Vision Research team of Cerebra at the Seattle Fremont office.
- Project was focused on developing a new technique for actively construct mini-batches for better performance in machine learning models optimized with stochastic gradient descent (SGD).
  - Preliminary results showed a 2x reduction in training time to convergence, which if applied to all cloud training could cut the hardware and energy budgets of training models in half.
  - Currently documenting work and results for conference submission.
- Planned extension of this work would be to apply minibatch construction to lifelong learning on embodied platforms like robots.

Graduate Researcher – Georgia Institute of Technology, 2016-Present

- *Current research project*: continual learning of deep neural networks without catastrophic forgetting using semi-supervised data.
  - Biological creatures learn new concepts in the context of the world around them, neural networks do not and experience more forgetting.
  - Combining concepts from open set outlier detection, continual learning, semi-supervised learning, and statistical learning theory to develop a memory-free solution that performs comparably to methods that memorize examples from prior tasks.

- *Practical application:* any machine learning system with access to large amounts of unlabeled data and limited labeled data where the number of classes grows through the deployment of the system.

- Prior research project: investigated learning embedded representations of semantic objects by object co-occurrences in 3D context.
  - Explored how these "spatial context object embeddings", learned on data mined from the SUNGC dataset, can be used to quantify the orderliness of a scene; suggest mappings of "out-of-place" objects to new locations.
  - *Practical application:* an autonomous "tidying-up" robot for to home, hospitals, and disaster zones.
  - *Practical application:* active workspace management for making human workers more efficient.
- Prior research project: "Macgyvering" tool construction by visual comparison for robot problem solving.
  - Given a task, a reference tool necessary for solving a task which is not in the environment, and objects in the environment, enable a robot construct a new tool that can also complete the task using the visual geometry of the reference tool.
  - Paper accepted for publication and presentation at the International Conference on Robotics and Automation, 2019.
- Prior research project: ways in which synthetic visual data generated from simulation can benefit real-time semantic segmentation for a robot
  - Investigated the degree to which pretraining on a large amount of synthetic data improves performance on real data
  - Showed that our method of training on synthetic data in a curriculum outperforms both training from scratch and standard data augmentation practices like pretraining on ImageNet.
  - Investigated the importance of the similarity of synthetic data to the real data when being trained in a curriculum, and show that while similarity is beneficial, more data has even greater benefits.
  - *Practical application*: improving pretraining of features for finetuning on limited application data.
  - Work presented at workshop at 2017 Conference on Robotics: Science and Systems, full paper submitted to ArXiv in 2018.

Robotics Engineer – Intelligent Automation, Inc., 2013-2016

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- Specialized in design and development of computer vision, sensor fusion, and control algorithms for robotics.
- Collaborated with UCLA on the DARPA MSEE and SIMPLEX projects
  - Leading the effort working with a Baxter robot for autonomous furniture assembly of IKEA table
  - Developed C++ Windows interface allowing Baxter control over TCP and camera functionality over UDP
- C++ computer vision research development for Bearing-based Landmark Navigation robotic system for Army in collaboration with Rutgers:
  - Improved contour feature tracking algorithm to object segmentation persistence of 94% using mean shift and optimized code to increase run-time efficiency from 0.4 fps to 3 fps with HD streaming input.
  - Designed omnidirectional camera sensor head from four cameras with IMU and developed API for integration with our robot platform
- Implemented mobility and OCU control systems for dual-manipulator robot and localization for maintainer robot as part of Multi-Arm Robotic Control System program for the Navy as part of the AEODRS effort
  - Led integration effort of our robotic control system, Behavior Development Studio, with the AEDORS 2.0 standard, making it compatible with all five modules
  - Demonstrated ease of use and high-level control with limited operator training at the DARPA Robotic Challenge Trials Expo in Homestead, FL in December 2013

Graduate Student Researcher – GRASP Lab, University of Pennsylvania, 2012-2013

- Worked with team on the DARPA Robotics Challenge Track B "TROOPER" Team in cooperation with Lockheed Martin to simulate and deploy a humanoid rescue robot.
- Enabled walking and standing stability by implementing impedance control and ZMP algorithms in ROS using C++
- Assisted with the design and implementation of a machine learning/vision assignment to identify and grasp a hose.

Graduate Research Intern – Lockheed Martin Advanced Technology Center, 2012

- Developed a MATLAB package which reduced digital noise and increased accuracy in laser simulations.

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- Benchmarked a new high-performance computer (HPC) for radiative transfer plume analysis, and contributed to a real-time radiative transfer analysis Python program that increased the HPC efficiency by an order of magnitude.

Planetary Science Intern – NASA Jet Propulsion Laboratory, 2010

- Funded through the NASA Space Grant. Modeled radiative transfer in Titan's detached haze layer in FORTRAN.
- Discovered and published on the rapid change in the altitude and eccentricity of Titan's atmosphere over time.
- Published findings in *Geophysical Research Letters*

Teaching Experience

CS7642: Reinforcement Learning (TA) – Georgia Institute of Technology, 2019

CS6476: Computer Vision (TA) – Georgia Institute of Technology, 2017

CS4641: Machine Learning (TA) – Georgia Institute of Technology, 2016

ESE-505: Introduction to Control Systems (TA) – University of Pennsylvania, 2013

MEAM-510: Mechatronic Systems (TA) – University of Pennsylvania, 2012

PHYS-252: Electricity and Magnetism (Head TA/Lecturer) – Georgetown University, 2010-2011

PHYS-101/102: Intro to Physics (TA) – Georgetown University, 2009-2011

Technical Skills

Python, SciPy Stack, PyTorch, TensorFlow, LaTeX, ROS/Gazebo/RViz, Linux/bash, C++, Caffe, OpenCV, Boost, C, MATLAB, Arduino, PCL, OpenNI, Blender, GIMP/Inkscape, JAVA, XML, Windows Batch, Qt, Android, EJM, SolidWorks, Mathematica

Volunteer Leadership Experience

Vice President, RoboGrads Student Organization – Georgia Institute of Technology, 2017-Present

- Acted as intermediary between the students and robotics faculty
- Helped facilitate updates to the Robotics Qualifying Exam
- Organized events to enable networking between students and professors interested in robotics and AI across multiple schools and disciplines

FIRST Robotics Mentor – Team 449, *Montgomery Blair High School, MD* 2014-2016

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- Helped high school students understand engineering process using games played by robots built by the team. I have mainly helped the students understand and learn Java using the WPILib FRC Controls System, mentored the software team on how to debug their code.