

Research Interests

My goal is to create algorithms that amplify the abilities of scientists, doctors, and other human experts. My work bridges the gap between traditional machine learning techniques and the challenges faced by human experts, including fine-grained categories, heterogeneous side information, and scarce/noisy/biased labels. I also use these real-world problems as the basis for new benchmark datasets, which measure algorithmic innovation in terms of progress on impactful applications.

Education

California Institute of Technology **Sep 2017 - Present**
Ph.D. in Computing and Mathematical Sciences
Thesis Committee: Pietro Perona (advisor), Serge Belongie, Katie Bouman, Yisong Yue
Expected Completion: June 2023

Duke University **Aug 2013 - May 2017**
Bachelor of Science in Engineering
Double Major in Electrical and Computer Engineering, Mathematics

Experience

California Institute of Technology **Sep 2017 - Present**
Position: Ph.D. Student
Supervisor: Pietro Perona

Google Research **Jun 2020 - Present**
Position: Student Researcher
Supervisors: Kimberly Wilber, Christine Kaeser-Chen, Serge Belongie

Microsoft Research **Summer 2019**
Position: Research Intern
Supervisors: Dan Morris, Nebojsa Jojic

Air Force Research Laboratory **Summer 2017, Summer 2018**
Position: Research Intern
Supervisor: Asif Mehmood

Duke University (Vision and Image Processing Lab) **Nov 2015 - May 2017**
Position: Undergraduate Researcher
Supervisor: Sina Farsiu

Duke University (Systems Architecture Integration Laboratory) **Mar 2016 - Dec 2016**
Position: Undergraduate Researcher
Supervisor: Benjamin Lee

Duke University Marine Lab (Nowacek Group) **Summer 2015**
Position: Undergraduate Researcher
Supervisor: Douglas Nowacek

Duke University Marine Lab (Van Dover Group / WHOI)

Summer 2014, Summer 2015

Position: Undergraduate Researcher

Supervisors: Cindy Lee Van Dover, Carl Kaiser

Publications ([Google Scholar](#))

Journal and Conference Papers

1. **Elijah Cole**, Xuan Yang, Kimberly Wilber, Oisín Mac Aodha, Serge Belongie. “When Does Contrastive Visual Representation Learning Work?” IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2022.
2. Sara Beery*, **Elijah Cole***, Joseph Parker, Pietro Perona, Kevin Winner. “Species Distribution Modeling for Machine Learning Practitioners: A Review.” ACM Computing and Sustainable Societies (COMPASS), 2021.
3. **Elijah Cole**, Oisín Mac Aodha, Titouan Lorieul, Pietro Perona, Dan Morris, Nebojsa Jojic. “Multi-Label Learning from Single Positive Labels.” IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2021.
4. Grant Van Horn, **Elijah Cole**, Sara Beery, Kimberly Wilber, Serge Belongie, Oisín Mac Aodha. “Benchmarking Representation Learning for Natural World Image Collections.” IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2020. Oral.
5. Oisín Mac Aodha, **Elijah Cole**, Pietro Perona. “Presence-Only Geographical Priors for Fine-Grained Image Classification.” International Conference on Computer Vision (ICCV), 2019.
6. Theodore B. DuBose, David Cunefare, **Elijah Cole**, Peyman Milanfar, Joseph A. Izatt, Sina Farsiu. “Statistical Models of Signal and Noise and Fundamental Limits of Segmentation Accuracy in Retinal Optical Coherence Tomography.” IEEE Transactions on Medical Imaging (TMI), 2018.
7. James Polans, David Cunefare, **Elijah Cole**, Brenton Keller, Priyatham S. Mettu, Scott W. Cousins, Michael J. Allingham, Joseph A. Izatt, Sina Farsiu. “Enhancing Visualization of Peripheral Retinal Vasculature with Wavefront Sensorless Adaptive Optics OCT Angiography in Diabetic Patients.” Optics Letters, 2017.
8. James Polans, Brenton Keller, Oscar M. Carrasco-Zevallos, Francesco LaRocca, **Elijah Cole**, Heather E. Whitson, Eleonora M. Lad, Sina Farsiu, Joseph A. Izatt. “Wide-field retinal optical coherence tomography with wavefront sensorless adaptive optics for enhanced imaging of targeted regions.” Biomedical Optics Express, 2017.
9. Seyed Majid Zahedi, Songchun Fan, Matthew Faw, **Elijah Cole**, Benjamin C. Lee. “Computational Sprinting: Architecture, Dynamics, and Strategies.” ACM Transactions on Computer Systems (TOCS), 2017.
10. Avery B. Paxton, J. Christopher Taylor, Douglas P. Nowacek, Julian Dale, **Elijah Cole**, Christine M. Voss, Charles H. Peterson. “Seismic survey noise disrupted fish use of a temperate reef.” Marine Policy, 2017.
11. Andrew Billings, Carl Kaiser, Craig M. Young, Laurel S. Hiebert, **Elijah Cole**, Jamie K.S. Wagner, Cindy Lee Van Dover. “SyPRID Sampler: A Large-Volume, High-Resolution, Autonomous, Deep-Ocean Precision Plankton Sampling System.” Deep-Sea Research II: Topical Studies in Oceanography, 2016.
12. Martin Brooke, **Elijah Cole**, Julian Dale, Anshuman Prasad, Henry Quach, Becca Bau, Eeshan Bhatt, Douglas Nowacek. “An ocean sensor for measuring the seawater electrochemical response of 8 metals referenced to zinc, for determining ocean pH.” IEEE International Conference on Sensing Technology (ICST), 2015.

Workshop, Dataset, and Competition Papers

1. Sara Beery, Arushi Agarwal, **Elijah Cole**, Vighnesh Birodkar. “The iWildCam 2021 Competition Dataset.” CVPR Workshop on Fine-Grained Visual Categorization (FGVC), 2021.
2. Titouan Lorieul, **Elijah Cole**, Benjamin Deneu, Maximilien Servajean, Pierre Bonnet, Alexis Joly. “Overview of GeoLifeCLEF 2021: Predicting species distribution from 2 million remote sensing images.” Conference and Labs of the Evaluation Forum (CLEF), 2021.
3. Sara Beery, **Elijah Cole**, Arvi Gjoka. “The iWildCam 2020 Competition Dataset.” CVPR Workshop on Fine-Grained Visual Categorization (FGVC), 2020.
4. Benjamin Deneu, Titouan Lorieul, **Elijah Cole**, Maximilien Servajean, Christophe Botella, Pierre Bonnet, Alexis Joly. “Overview of LifeCLEF location-based species prediction task 2020 (GeoLifeCLEF).” Conference and Labs of the Evaluation Forum (CLEF), 2020.
5. **Elijah Cole**, Benjamin Deneu, Titouan Lorieul, Maximilien Servajean, Christophe Botella, Dan Morris, Nebojsa Jojic, Pierre Bonnet, Alexis Joly. “The GeoLifeCLEF 2020 Dataset.” arXiv, 2020.
6. Oisin Mac Aodha, **Elijah Cole**, Pietro Perona. “Presence-Only Geographical Priors for Fine-Grained Image Classification.” ICCV Workshop on Computer Vision for Wildlife Conservation, 2019. Oral.

Posters and Abstracts

1. **Elijah Cole**, Asif Mehmood. “Signal Modeling via Optimal Partitioning.” Air Force Research Laboratory Summer Workshop, 2018.
2. **Elijah Cole**, Asif Mehmood. “Quantization Bounds and Short-Signal Frequency Estimation.” Air Force Research Laboratory Summer Workshop, 2017.
3. **Elijah Cole**, David Cunefare, Paul Bendich, Sina Farsiu. “OCT Image Segmentation Using Topological Persistence: Properties and Performance.” Duke ECE Independent Study Spring Poster Session, 2017. 1st Place Best Poster.
4. **Elijah Cole**, David Cunefare, Paul Bendich, Sina Farsiu. “Automatic Segmentation of Retinal Layers in OCT Images Using Topological Persistence.” Duke ECE Independent Study Fall Poster Session, 2016. 1st Place Best Poster.
5. **Elijah Cole**, James Polans, Joseph A. Izatt, Sina Farsiu. “Comparing the Convergence Speed and Repeatability of Sensorless Adaptive Optics Optimization Algorithms for Optical Coherence Tomography.” Duke ECE Independent Study Spring Poster Session, 2016.
6. Phillip J. Turner, Bernard Ball, **Elijah Cole**, Abigail LaBella, Jamie Wagner, Cindy Lee Van Dover, Adam D. Skarke, Carolyn D. Ruppel. “SeepC: Preliminary Characterization of Atlantic Margin Seep Ecosystems from Norfolk Canyon to New England Seep Sites.” American Geophysical Union (AGU), 2015.
7. Cindy Lee Van Dover, Carl Kaiser, Craig M. Young, Andrew Billings, **Elijah Cole**. “SeepC: Concept, design, and test of a high-resolution AUV Deep-Ocean Plankton Sampler (DOPS).” International Deep-Sea Biology Symposium, 2015.
8. Martin Brooke, **Elijah Cole**. “Low Power Sensors built using Open Source Hardware.” mHealth@Duke, 2015.

Talks

“Self-Supervised Learning Beyond ImageNet: Expert Tasks as New Frontiers.”

- Michigan State University, May 2022.
- Arizona State University, March 2022.

“Geographical Priors for Image Classification.”

- LifeCLEF Workshop, September 2020.

“Species Distribution Models as Geographical Priors” (with Sara Beery).

- Yale University, Species Distribution Modeling Workshop, September 2020.

“Computer Vision for Biodiversity Monitoring and Conservation” (with Sara Beery).

- Yale University, Center for Biodiversity and Global Change Seminar, February 2020.

“Fine-Grained Classification and Geospatial Data.”

- Cornell Tech, Visipedia Retreat, February 2020.

Lectures and Tutorials

“Research and Publishing in Computer Vision.”

- Caltech, EE/CNS/CS 148: Selected Topics in Computational Vision, May 2022.

“A Conceptual Introduction to Computer Vision for Remote Sensing.”

- BioscienceLA, AILA Open Innovation Challenge Kick-Off Day, March 2022.

“Unsupervised and Self-Supervised Learning.”

- Caltech, EE/CNS/CS 148: Selected Topics in Computational Vision, May 2020.

Teaching

Resnick Sustainability Institute Summer School on Computer Vision for Ecology

Role: Instructor

Taught at Caltech: Summer 2022

Selected Topics in Computational Vision

Role: Graduate Teaching Assistant

Taught at Caltech: Spring 2020, Spring 2021, Spring 2022

Fundamentals of Electrical and Computer Engineering

Role: Undergraduate Teaching Assistant

Taught at Duke University: Spring 2015, Fall 2015, Spring 2017

Computational Methods in Engineering.

Role: Undergraduate Teaching Assistant

Taught at Duke University: Spring 2014

Research Advising and Consulting

Snigdha Saha, Caltech Undergraduate Student	2022 - Present
Patrick Rim, Caltech Undergraduate Student	2022 - Present
Mihai Toma, Caltech Postdoctoral Scholar	2022 - Present
Rupa Kurinchi-Vendhan, Caltech Undergraduate Student	2022 - Present
Julio Arroyo, Caltech Undergraduate Student	2021 - Present
George Ore, Caltech Undergraduate Student	Summer 2021
Daniel Nagles, Caltech Undergraduate Student	Summer 2020
Yibing Wei, Caltech Master's Student	2020
Johanna Garcia, JPL Engineer	2019 - 2020
Marcus Dominguez-Kuhne, Caltech Undergraduate Student	2019

Funding

Resnick Sustainability Institute Explorer Grant (\$120k) “Automated Ecological Monitoring: Learning from Context.” Sara Beery, Elijah Cole, Pietro Perona.	2021
NSF Graduate Research Fellowship (\$138k) “Community-in-the-Loop Species Distribution Modeling.” Elijah Cole.	2019

Honors and Awards

Resnick Sustainability Institute Scholar	2021
CVPR Outstanding Reviewer	2021
ICLR Outstanding Reviewer	2021
ICML Expert Reviewer	2021
NeurIPS Top 10% High Scoring Reviewer	2020
NSF Graduate Research Fellowship	2019
Computing and Mathematical Sciences Fellowship, Caltech	2017
Charles Ernest Seager Memorial Award, Duke University - Awarded for best thesis and oral defense in the Electrical and Computer Engineering department	2017
Thesis with Distinction in Electrical and Computer Engineering, Duke University - “Automatic Segmentation of Retinal Layers in OCT Images using Topological Persistence”	2017

Bachelor of Science in Engineering <i>cum laude</i> , Duke University	2017
SMART Scholarship, United States Department of Defense - 14% award rate, unable to accept	2017
Associate Member, Sigma Xi Scientific Research Honor Society	2017
1st Place Best Poster, Spring ECE Independent Study Poster Session, Duke University	2017
1st Place Best Poster, Fall ECE Independent Study Poster Session, Duke University	2016
Member, Tau Beta Pi Engineering Honor Society	2016
Pratt Research Fellowship, Duke University - Support for 18 months of undergraduate research.	2015
Invited Guest Student, Woods Hole Oceanographic Institution	2014

Professional Activities

Outreach

Hour of Code Presenter (“CS + Ecology”), Bryant Elementary School (Seattle, WA)	Jan 2021
Mentor, Freshman Summer Research Institute (FSRI), Caltech	2020, 2021
Mentor, Summer Research Connection (SRC) Program, Caltech	2021
Classroom Visit, Tom C. Clark High School (San Antonio, TX)	Aug 2019

Institutional Service

DEI Steering Committee, Computing & Mathematical Sciences Department, Caltech	2021 - Present
Admissions Committee, Computing & Mathematical Sciences Department, Caltech	2021, 2022
Quantitative Ecology Initiative Committee, Resnick Sustainability Institute, Caltech	2020 - Present

Organizing

Workshop on Fine-Grained Visual Categorization (FGVC)

Role: Co-organizer (Paper Chair)
Held at CVPR: 2021, 2022

GeoLifeCLEF Competition

Role: Co-organizer
Held: 2020, 2021, 2022

iWildCam Competition

Role: Co-organizer
Held: 2020, 2021

Reviewing

Conferences: CVPR ('21, '22), ICML ('21, '22), ICLR ('21), NeurIPS ('20), WACV ('20), ICCV ('19).

Workshops: CVPR Workshop on Fine-Grained Visual Categorization ('20, '21, '22), CLEF ('21, '22), Harvard Center for Research on Computation and Society Workshop on AI for Social Good ('20), WACV Workshop on Deep Learning Methods and Applications for Animal Re-Identification ('20), NeurIPS Workshop on Machine Learning and the Physical Sciences ('19, '20)

Journals: Artificial Intelligence (Elsevier), Biomedical Optics Express (Optica).

Other: Climate Change AI Innovation Grants ('21).