

David Cox, Ph.D.

Curriculum Vitae | January 2013

Contact Information

52 Oxford St., NWL 219.40
Cambridge, MA 02138
phone: (857) 209-4089
assistant: (617) 384-7328
fax: (617) 496-5425
email: davidcox@fas.harvard.edu
www: <http://coxlab.org>

Academic Appointments

Assistant Professor of Molecular and Cellular Biology and of Computer Science – 2012-present

Faculty of Arts and Sciences, School of Engineering and Applied Sciences and
Center for Brain Science
Harvard University

Rowland Junior Fellow – 2007-2012

The Rowland Institute at Harvard
Harvard University, School of Engineering and Applied Sciences

Education

Massachusetts Institute of Technology, Cambridge, MA – 2002-2007

Ph.D. in Neuroscience (major area of concentration in computational neuroscience)
Advisor: James DiCarlo, M.D., Ph.D.

Harvard University, Cambridge, MA – 1996-2000

A.B. Biology and Psychology
Highest Honors in Biology and Psychology

Research Summary

We recognize visual objects with such ease that it is easy to overlook what an impressive computational feat this represents. Any given object in the world can cast an infinite number of different images onto the retina, depending on its position relative to the viewer, the configuration of light sources, and the presence of other objects in the visual field. In spite of this extreme variation, biological visual systems are able to effortlessly recognize hundreds of thousands of distinct object classes—a feat that no current artificial system can come close to achieving.

My laboratory seeks to understand the computational underpinnings of object recognition through a concerted effort on two fronts. First, we endeavor to understand the workings of biological visual systems using a variety of experimental techniques, ranging from microelectrode recordings to visual psychophysics. Second, we attempt to instantiate what we have learned into artificial object recognition systems, leveraging recent advances in parallel computing to build systems that begin to approach the scale of natural systems. By combining reverse- and forward-engineering approaches, we hope to accelerate progress in both domains.

Publications

Journal Papers

1. Pinto N, **Cox DD** (2012) High-Throughput-Derived Biologically-Inspired Features for Unconstrained Face Recognition. *Image and Vision Computing* 30(3): 159-168.
2. Zoccolan D, Graham B, **Cox DD** (2010) A Self-Calibrating Infrared Eye-Tracking System for Use with Rodents. *Frontiers in Neuroscience Methods*. doi:10.3389/fnins.2010.00193.
3. Zoccolan, DF, Oertelt, N, DiCarlo, JJ, **Cox, DD**. (2009) A Rodent Model for the Study of Invariant Visual Object Recognition. *Proceedings of the National Academy of Sciences* doi:10.1073/pnas.0811583106
4. Pinto N, Doukhan D, DiCarlo JJ, and **Cox DD**. (2009) A High-Throughput Approach to Biologically-Inspired Object Recognition. *PLoS Computational Biology*. 5(11): e1000579. doi:10.1371/journal.pcbi.1000579.
5. Li N, **Cox DD**, Zoccolan D, DiCarlo JJ (2009) What response properties do individual neurons need to underlie position and clutter “invariant” object recognition? *Journal of Neurophysiology* 102(1): 360-76.
6. **Cox DD**, Dicarlo JJ (2008) Does Learned Shape Selectivity in Inferior Temporal Cortex Automatically Generalize Across Retinal Position? *Journal of Neuroscience*, 28(40):10045-10055.
7. **Cox DD**, Papanastassiou A, Oreper D, Andken B, DiCarlo JJ (2008) High-Resolution Three-Dimensional Microelectrode Brain Mapping Using Stereo Microfocal X-Ray Imaging. *Journal of Neurophysiology* 100(5):2966-76.
8. Mujica-Parodi L, Strey H, Frederick B, Savoy RL, **Cox DD**, Botanov Y, Tolkunov D, Rubin D, Weber J (2008) Chemosensory Cues to Conspecific Emotional Stress Activate the Amygdala in Humans. *PLoS ONE* 4(7):e6415
9. Pinto N*, **Cox DD*** (contributed equally), DiCarlo JJ. (2008) Why is Real World Object Recognition Hard? *PLoS Computational Biology* 4(1):e27
10. Balas B, **Cox DD**, Conwell E (2007) The Effect of Real-World Personal Familiarity on the Speed of Face Information Processing. *PLoS One* 2(11):e1223
11. DiCarlo JJ and **Cox DD**. (2007) “Untangling” Invariant Object Recognition. *Trends in Cognitive Science*, 11(8): 333-341.
12. **Cox DD**, Meier P, Oertelt N, DiCarlo JJ (2005) 'Breaking' Position-Invariant Object Recognition. *Nature Neuroscience*, 8: 1145-1147.
13. Zoccolan DF*, **Cox DD*** (contributed equally), DiCarlo JJ (2005) Multiple object response normalization in monkey inferotemporal cortex. *Journal of Neuroscience*, 25(36): 8150-8164.
14. **Cox D**, Meyers E, Sinha P (2004) Contextually Evoked Object-Specific Responses in Human Visual Cortex. *Science* 304:115-117.

15. **Cox DD** & Savoy RL (2003) Functional Magnetic Resonance Imaging (fMRI) “Brain Reading:” Detecting and Classifying Distributed Patterns of fMRI Activity in Human Visual Cortex. *NeuroImage* 19: 261-270.

Peer-Reviewed Conference Papers (primary mode of publication in computer science fields)

16. Bergstra J, Yamins D, **Cox DD** (2013). Making a Science of Model Search: Hyperparameter Optimization in Hundreds of Dimensions for Vision Architectures. International Conference on Machine Learning.
17. Vig N, Dorr M, **Cox DD** (2012) Space-Variant Descriptor Sampling for Action Recognition Based on Saliency and Eye Movements. European Conference on Computer Vision.
18. Chiachia G, Pinto N, Schwartz W, Rocha A, Falcão A, **Cox DD** (2012) Person-Specific Subspace Analysis for Unconstrained Familiar Face Recognition. British Machine Vision Conference.
18. Vig N, **Cox DD** (2012) Saliency-based Selection of Sparse Descriptors for Action Recognition. *International Conference on Image Processing*.
19. Bergstra J, Pinto N, **Cox DD** (2012) Machine Learning for Predictive Auto-Tuning with Boosted Regression Trees. *Innovative Parallel Computing*.
20. Pinto N, **Cox DD** (2011) Scaling up Biologically-Inspired Computer Vision: a Case Study in Unconstrained Face Recognition on Facebook. *Workshop on Biologically Consistent Computer Vision at CVPR 2011*.
21. Pinto N, **Cox DD** (2011) Beyond Simple Features: A Large-scale Feature Search Approach to Unconstrained Face Recognition. *IEEE Automated Face and Gesture Recognition*.
22. Pinto N, **Cox DD** (2010) Evaluating the Invariance Properties of a Successful Biologically-Inspired Face Recognition System *ICST Bio-Inspired Models of Network, Information, and Computing Systems (BIONETICS 2010)*.
23. Sriram V, Tsoi K, Luk W, **Cox DD** (2010) Towards an Embedded Biologically-Inspired Machine Vision Processor. *IEEE Field Programmable Technology*.
24. Sriram V, Tsoi K, Luk W, **Cox DD** (2010) Design-Space Exploration of Biologically-Inspired Visual Object Recognition Algorithms Using CPUs, GPUs, and FPGAs. *Many-Core and Reconfigurable Supercomputing 2010*.
25. Pinto N, DiCarlo JJ, and **Cox DD**. (2009) How far can you get with a modern face recognition test set using only simple features? *IEEE Conf. on Computer Vision and Pattern Recognition 2009*
26. Pinto N, DiCarlo JJ, **Cox DD** (2008) Establishing Good Baselines and Benchmarks for Face Recognition. *Proceedings of the Faces in Real Life Images Workshop, ECCV 2008*.
oai:hal.inria.fr:inria-00326721_v1

Book Chapters

27. Pinto N, **Cox DD** (2011) GPU Meta-programming. *GPU Computing Gems, Volume 2, edited by Wen-mei Hwu, published by Morgan Kaufman*.

Select Abstracts

- Graham BJ, Carouso SV, Cox DD (2011) "3D Structured Illumination Imaging for Precise Stereotaxy and Electrode Placement in Rodents" Society for Neuroscience Annual Meeting 2011.
- Cox DD and Pinto N (2010) "Bridging GPU-computing, Neuroscience and Large-scale Face Recognition" NVIDIA GPU Technology Conference.
- Cox DD (2010) "A Large-Scale Feature-Search Approach to Invariant Object Recognition" Snowbird Learning Workshop.
- Cox DD (2008) "Untangling Invariant Visual Object Representations." COSYNE 08 Workshops
- Li N, Cox DD, Zoccolan D, DiCarlo JJ (2006) Flexible and robust object recognition supported by neurons with limited position and clutter tolerance. Society for Neuroscience Annual Meeting. Atlanta, GA
- Cox DD, DiCarlo JJ (2005) Is the Binding Problem Really a Problem in Inferotemporal Cortex? Society for Neuroscience Annual Meeting. Washington D.C.
- Cox DD, DiCarlo JJ (2004) The Effect of Visual Experience on the Position Tolerance of Primate Object Representations. Society for Neuroscience Annual Meeting. San Diego, CA.
- Cox DD, Savoy RL (2002) A Statistical Pattern Recognition Approach to fMRI. Annual Meeting of the Organization for Human Brain Mapping, Sendai, Japan.
- Cox DD, Savoy RL (2001) Detecting and Classifying Distributed Patterns of Activity in Human Visual Cortex. Society for Neuroscience Annual Meeting. San Diego, CA.

Presentations and Invited Lectures

- Neural Information Processing Systems Meeting, (2012) "Large-scale approaches to connectomics image analysis"
- MIT Lincoln Lab (2012) "Biologically-inspired approaches to computer vision"
- Janelia Farm (2012) "Scaling up biologically-inspired vision for connectomics"
- Google Research (2012) "High-throughput approaches to brain-inspired vision"
- Massachusetts Institute of Technology, Dept. of Brain and Cognitive Sciences, Vision Seminar (2012) "A rodent model for studying visual object recognition"
- Harvard Vision Lab Seminar, Dept. of Psychology (2012) "Biologically-inspired approaches to artificial face recognition"
- Johns Hopkins, Center for Imaging Science (2012) "Large-scale approaches to general-purpose machine vision"
- Johns Hopkins University, Dept. of Psych and Brain Sciences (2012)
- Johns Hopkins Medical School, Department of Neuroscience (2012) "A rodent model for the study of high-level vision"

Carnegie Mellon, Dept. of Biomedical Engineering (2012) “Reverse Engineering High-Level Vision”

Riken Brain Sciences Institute, Wako-shi, Japan (2011)

Carnegie Mellon, Dept. of Biology (2011)

Allen Institute for Brain Science (2011) “High-Throughput Rodent Behavior and Physiology”

Workshop on Biologically Consistent Vision at IEEE CVPR (2011) Keynote Lecture. “Ten things every computer vision researcher should know about neuroscience”

Brown University, Dept. of Applied Mathematics (2011) “Untangling Invariant Object Recognition: A High-throughput Approach”

Qualcomm Research, San Diego, CA (2011) “Scaling-up Biologically-Inspired Machine Vision”

Many Core and Reconfigure Supercomputing Conference, Rome, Italy (2010) “Towards an embedded vision processor”

GPU Technology Conference, San Jose, CA (2010) “Unlocking Biologically-Inspired Face Recognition: A Case Study on Facebook”

Harvard University, Bioengineering Symposium (2009) “Reverse and Forward Engineering High-Level Vision”

Aptina Corporation, San Jose, CA (2010) “Opportunities in biologically-inspired vision”

Snowbird Learning Workshop (2010)

Harvard University, Department of Computer Science (2009)

National Center for Supercomputing Applications, Great Lakes Virtual School on Petascale Computing. Keynote Lecture (2009)

NVISION, San Jose, CA (2008)

Harvard University, Center for Brain Science (2008)

Computational System Neuroscience, Multivariate Analysis Workshop (2008)

Massachusetts Institute of Technology, Dept. of Brain and Cognitive Sciences (2005)

fMRI Visiting Fellowship Program, Athinoula A. Martinos Center (2004)

American Psychological Association Advanced Training Institute, MGH (2003)

McGovern Institute 1st Annual Retreat, Massachusetts Institute of Technology (2003)

Athinoula A. Martinos Center, Massachusetts General Hospital (2002)

Select Open Source Projects

MWorks (<http://mworks-project.org>) Software for performing automated behavioral and neurophysiology experiments.

Self Calibrating Eyetracker (<http://www.github.com/coxlab/eyetracker>) Open source software and hardware for performing gaze tracking, especially in species that do not reliably produce volitional saccades

Stereo X-Ray Electrode Localization (<http://www.x-runner.org>) Software and hardware designs for stereo microfocal x-ray localization of implanted microelectrodes.

Audio Neurophysiology (<http://www.github.com/coxlab/spike-audio-unit/>) Software for performing online spike detection in Apple's Core Audio framework.

Portable Kinect (<http://www.rowland.harvard.edu/cox/projects/subprojects/kinect/>) A hardware mod to enable the Microsoft Kinect to be used as a portable depth camera.

Awards, Honors, and Fellowships

Rowland Junior Fellowship, Harvard University – 2007-2012

National Defense Science and Engineering Graduate Fellowship – 2003-2006

Harvard Committee on Undergraduate Education Certificate of Distinction in Teaching – 2000, 2001

Funding

Internal Funding

Rowland Junior Fellowship: 5-year, open-ended, direct endowment funding for lab operations. 2007-2012.

External Grants

IOS 0947777: "A Novel Rodent Model for the Neurophysiology of Visual Object Recognition." NSF. 2009-2011. \$150,000

IIS 0963668: "Collaborative Research: Unlocking Biologically-Inspired Computer Vision: A High-Throughput Approach." NSF. Co-PI: James DiCarlo. 2010-2013. \$820,000.

2010 Google Research Award. "A Large-Scale Feature Search Approach to Biologically-Inspired Computer Vision for the Analysis of Video." \$72,000.

Resource/In-Kind Grants

TeraGrid Startup Allocation. "A High-Throughput Approach to Biologically-Inspired Computer Vision." 35,000 compute-hours on the National Center for Supercomputing Applications "Lincoln" CPU/GPU Cluster

Amazon Web Services. In-kind cloud computing services.

NVIDIA Professor Partnership Program. In-kind GPU computing hardware.

Student and Postdoctoral Supervision

Undergraduate Students

Pauline Gassman (University of Iowa, class of 2009), Summer 2007, 2008

Minjae Kim (Harvard University, class of 2011), Independent Study, Spring 2009

Kyle Marra (Boston College, class of 2012) Summer of 2011

Christine Lee (Duke University, class of 2014) Summer of 2011

Visting Graduate Students

Chuan-Yung Tsai (National Taiwan University), 2011

Giovani Chiachia (University of Campinas, Brazil), 2012

Postdoctoral Fellows

Davide Zoccolan, Ph.D. (2007-2009) *A novel rodent model for studying invariant visual object recognition*. Current position: Assistant Professor, International School for Advanced Studies (SISSA), Trieste, Italy.

Vinay Sriram, Ph.D.(2009-2010) *Hardware architectures for embedded biologically-inspired machine vision*. Current position: Director of Engineering IPACS Australia Pty Ltd.

Brett Graham, Ph.D. (2010-present) *Neuronal substrates of high-level vision in rodents*.

Nicolas Pinto, Ph.D. (2011-present) *High-throughput biologically-inspired visual object recognition*.

Nicolas Poilvert, Ph.D. (2011-present)

James Bergstra, Ph.D. (2011-present)

Eleonora Vig, Ph.D. (2011-present)

Teaching

Guest Lecture, CS379C: Computational Models of Cortex (Stanford), Spring 2012

Guest Lecture ("Parallel Computing for Biologically-Inspired Vision") CS 264: Massively Parallel Computing (Harvard), Fall 2009.

Keynote Lecture, NCSA / Great Lakes Consortium for Petascale Computation Summer School: Many-Core Processors for Science and Engineering Applications, 2009

Guest Lecture ("Unlocking Biologically-Inspired Computer Vision: A High-Throughput Approach"), 6.963: CUDA@MIT (MIT), 2009

Guest Lecture ("Resampling Statistics"), 9.07: Introduction to Statistical Methods (MIT) – Spring 2006

Teaching Assistant, 9.02: Brain Laboratory (MIT) – Spring 2006

Invited Speaker, Advanced Training Institute in Functional MRI (American Psychological Association) – 2005

Teaching Assistant, 9.011 Systems Neuroscience (MIT) – Fall 2004

Teaching Assistant, 9.00 Introduction to Psychology (MIT) – Fall 2003

Teaching Assistant, Functional MRI Visiting Fellowship Program (Massachusetts General Hospital) – 2000-2006

Teaching Assistant, Psychology 1251, Introduction to Functional Neuroimaging Methods (Harvard) – Fall 2000, 2001

Professional Service

Peer Review

Reviewer for *Neuron*, *Journal of Neurophysiology*, *Journal of Neuroscience*, *Journal of Vision*, *Cortex*, *Cerebral Cortex*, *Cognitive Science*, *NeuroImage*, *Human Brain Mapping*, *IEEE Transactions in Medical Imaging*, *IEEE Transactions in Pattern Analysis and Machine Intelligence*, *Neural Processing Letters*, *Neural Computation*, *Journal of Visual Communication and Image Processing*, *PLoS One*, *PLoS Computational Biology*, *Trends in Cognitive Science*, and *Brain and Behavioral Sciences*, *Neural Information Processing Systems (NIPS)*, *Frontiers in Neuroscience*, *Frontiers in Perceptual Science*.

Ad hoc and panel reviewer for the National Science Foundation

Conference / Workshop Organization

Program Committee, Computational Systems Neuroscience (Cosyne) 2011

Program Committee, ICST Bio-Inspired Models of Network, Information, and Computing Systems 2010.

Organizing Committee, Workshop on Biologically-Consistent Computer Vision, IEEE CVPR 2011

Program Committee, Workshop on Applications of Computer Vision (WACV 2012)