

# Connelly Barnes

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*Assistant Professor, Computer Science Department, University of Virginia*

## CONTACT INFORMATION

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## RESEARCH INTERESTS

My research interests are in *computer graphics*. My research group at the University of Virginia develops techniques for efficiently manipulating visual data in computer graphics by using semantic information from computer vision. Our applications are in computational photography, image editing, art, and hiding visual information. We have recently been using deep learning in our research. Many computer graphics algorithms are more useful if they are interactive, therefore, we also have a focus on efficiency and optimization, including compiler technologies for visual computing.

I have a total of 13 papers accepted to ACM Transactions on Graphics. These are presented at the top graphics conferences SIGGRAPH and SIGGRAPH Asia.

## EDUCATION

### **Princeton University**

Ph.D. Computer Science, May 2011 (also M.A. Computer Science, 2009)

Thesis: PatchMatch: A Fast Randomized Matching Algorithm with Application to Image and Video

Dissertation Advisor: Adam Finkelstein

My Ph.D. research was technology transferred as a headline feature of Photoshop CS5. I received a Gordon Wu Prize for Excellence in research from Princeton University for this work. Our research has been viewed by 8 million viewers on YouTube [39] [40]. In later Photoshop versions, Content-aware Move, Patch Tool, and Color Adaptation were built on this technology.

### **Oregon State University**

Honors B.S. Mathematics, June 2006 (*summa cum laude*, GPA 4.0/4.0)

Honors B.S. Computational Physics, June 2006 (*summa cum laude*, GPA 4.0/4.0)

## EXPERIENCE

**University of Virginia**, Assistant Professor, Charlottesville, VA, August 2013 - present.

Lead computer graphics research lab, fundraiser, teach classes, serve on committees.

**Tsinghua University**, visiting professor hosted by professor Shi-Min Hu, summer 2014 and 2015.

**Postdoctoral Research Scientist**, Adobe Research, Cambridge, MA

August 2011 to August 2013.

Collaborated with professors Frédo Durand and Bill Freeman at MIT, where I was an affiliated researcher. Co-advised three research interns from ETH Zurich and MIT. Co-advised also a Ph.D. student at MIT as well as on projects with Ph.D. and Masters students at Princeton.

**Research Intern**, Microsoft Research, Redmond, WA

Summer 2010. Advised by Hugues Hoppe.

**Research Intern**, Adobe Advanced Technology Lab (now called Adobe Research), Seattle, WA

Summer 2008, spring and summer 2009. Advised by Eli Shechtman and Dan B Goldman.

**Undergraduate Educational Software Development**, Oregon State University

Summers, 2002-2006.

Worked with Professor Milo Koretsky. Developed chemical engineering education software ThermoSolver and VirtualCVD. These remain in use for education at Oregon State University, and have been used at other universities such as Berkeley and University of Oregon.

## FUNDING

- Co-PI, NSF HCC: Large Collaborative Research: Beyond Flat Images: Acquiring, Processing, and Fabricating Visually Rich Material Appearance (2015-2016). About \$260k was expensed to that grant for my group and overhead.
- PI, NSF SHF: Small: Translating Compilers for Visual Computing in Dynamic Languages (2016-2019). \$450k total, with about \$225k allocated to my group.
- Adobe gift funding. \$34k.
- Chinese Scholarship Council scholarship for student Liming Lou (2014-2016). This fully supported visiting Ph.D. student Liming.

## AWARDS

- Gordon Wu Prize for Excellence in scholarship and research (2010)
- National Merit scholarship (2003-2006)
- Intel American Electronics Association scholarship (2003-2006)
- Rensselaer Polytechnic medal and scholarship (2002)

## SUPERVISED GRADUATE STUDENTS

Masters of Science students at the University of Virginia:

- Zack Verham (current student)
- Paul Nguyen (graduated in 2015)
- Shanshan He (graduated in 2015)

Current Ph.D. students at the University of Virginia:

- Ning Yu
- Yuting Yang
- Fuwen Tan.

## SUPERVISED VISITING PH.D.

Visiting Ph.D. student at the University of Virginia:

- Liming Lou (visiting student from Shandong University, China from Fall 2014 to Spring 2016, Ph.D. received 2017).

## SUPERVISED UNDERGRADUATE THESES

Undergraduate Theses at the University of Virginia:

- Benjamin Cohen and Crispin Bernier, 2017. Thesis titles are yet to be determined.
- A Translating Compiler for Visual Computing in Dynamic Languages, Sam Prestwood, 2016.
- 3D Structure from Motion Viewer Utilizing Texture Projection, Nicholas Bergh, 2015.
- Audiovisual Performance in Virtual Reality, Jonathan Thompson, 2013.
- Interactive Stereo Depth Estimation for Image Based Rendering, Puneet Lall, 2013.

## TEACHING

At the University of Virginia:

- C.S. 4501 – Introduction to Computer Vision, Spring 2017.
- C.S. 6501 – Deep Learning for Computer Graphics, Fall 2016.
- C.S. 4810 – Introduction to Computer Graphics, Spring 2016.
- C.S. 6501 – Large-scale Data-driven Graphics and Vision, Fall 2015.
- C.S. 4810 – Introduction to Computer Graphics, Spring 2015.
- C.S. 6501 – Computational Photography, Fall 2014.
- C.S. 6501 – 2D/3D Shape Manipulation, 3D Printing, Spring 2014.
- C.S. 6501 – Computational Photography, Fall 2013.

- [1] **Where and Who? Automatic Semantic-Aware Person Composition.** Fuwen Tan, Crispin Bernier, Benjamin Cohen, Vicente Ordonez, Connelly Barnes. *arXiv preprint, 2017.*
- [2] **Approximate Program Smoothing Using Mean-Variance Statistics, with Application to Procedural Shader Bandlimiting.** Yuting Yang, Connelly Barnes. *arXiv preprint, 2017.*
- [3] **Stable and Controllable Neural Texture Synthesis and Style Transfer Using Histogram Losses.** Eric Risser, Pierre Wilmot, Connelly Barnes. *arXiv preprint, 2017.*
- [4] **Automatic Image Defect Diagnosis.** Ning Yu, Xiaohui Shen, Zhe Lin, Radomir Mech, Connelly Barnes. *arXiv preprint, 2017.*

- [5] **Halide: A Language and Compiler for Optimizing Parallelism, Locality, and Recomputation in Image Processing Pipelines.** Jonathan Ragan-Kelley, Andrew Adams, Connelly Barnes, Sylvain Paris, Fredo Durand, Saman Amarasinghe. *Invited paper for Communications of the ACM research highlights, accepted, to appear in 2017. These are invitation-only publications “devoted to the most significant recent research results published in computing.”*
- [6] **A Survey of the State-of-the-art in Patch-based Synthesis.** Connelly Barnes, Fang-Lue Zhang. *Computational Visual Media 2016.*
- [7] **VizGen: Accelerating Visual Computing Prototypes in Dynamic Languages.** Yuting Yang, Sam Prestwood, Connelly Barnes. *ACM Transactions on Graphics (Proc. SIGGRAPH Asia 2016).*
- [8] **Image Perforation: Automatically Accelerating Image Pipelines by Intelligently Skipping Samples.** Liming Lou, Paul Nguyen, Jason Lawrence, Connelly Barnes. *ACM Transactions on Graphics (Proc. SIGGRAPH 2016).*
- [9] **Towards Automatic Band-Limited Procedural Shaders.** Jonathan Dorn, Connelly Barnes, Jason Lawrence, Westley Weimer. Pacific Graphics 2015.
- [10] **PatchTable: Efficient Patch Queries for Large Datasets and Applications.** Connelly Barnes, Fang-Lue Zhang, Liming Lou, Xian Wu, Shi-Min Hu. *ACM Transactions on Graphics (Proc. SIGGRAPH 2015).*
- [11] **Synthesis of Complex Image Appearance from Limited Exemplars.** Olga Diamanti, Connelly Barnes, Sylvain Paris, Eli Shechtman, Olga Sorkine-Hornung. *ACM Transactions on Graphics 2015.*
- [12] **RealPigment: Paint Compositing by Example.** Jingwan Lu, Stephen DiVerdi, Willa Chen, Connelly Barnes, Adam Finkelstein. *NPAC 2014: Symposium on Non-Photorealistic Animation and Rendering, sponsored by ACM SIGGRAPH.*
- [13] **Stylized Keyframe Animation of Fluid Simulations.** Mark Browning, Connelly Barnes, Samantha Ritter, Adam Finkelstein. *NPAC 2014: Symposium on Non-Photorealistic Animation and Rendering, sponsored by ACM SIGGRAPH.*
- [14] **Style Transfer for Headshot Portraits.** YiChang Shih, Sylvain Paris, Connelly Barnes, Frdo Durand, William Freeman. *ACM Transactions on Graphics (Proc. SIGGRAPH Asia 2014).*

- [15] **DecoBrush: Drawing Structured Decorative Patterns by Example.** Jingwan Lu, Connelly Barnes, Connie Wan, Adam Finkelstein, Paul Asente, Radomir Mech. *ACM Transactions on Graphics (Proc. SIGGRAPH 2014)*.
- [16] **Camouflaging an Object from Many Viewpoints.** Andrew Owens, Connelly Barnes, Alex Flint, Hanumant Singh, Bill Freeman. *IEEE Computer Vision and Pattern Recognition 2014 (oral presentation, acceptance rate: 6%)*.
- [17] **Patch-based High Dynamic Range Video.** Nima Khademi Kalantari, Eli Shechtman, Connelly Barnes, Soheil Darabi, Dan B Goldman, Pradeep Sen. *ACM Transactions on Graphics (Proc. SIGGRAPH Asia 2013)*.
- [18] **RealBrush: An Example-based Painting System.** Jingwan Lu, Connelly Barnes, Stephen DiVerdi, Adam Finkelstein. *ACM Transactions on Graphics (Proc. SIGGRAPH 2013)*.
- [19] **Halide: A Language and Compiler for Optimizing Parallelism, Locality, and Recomputation in Image Processing Pipelines.** Jonathan Ragan-Kelley, Connelly Barnes, Andrew Adams, Sylvain Paris, Frédo Durand, and Saman Amarasinghe. *ACM SIGPLAN Conference on Programming Language Design and Implementation (PLDI) 2013, June*.
- [20] **Image Melding: Combining Inconsistent Images using Patch-based Synthesis.** Soheil Darabi, Eli Shechtman, Connelly Barnes, Dan B Goldman, and Pradeep Sen. *ACM Transactions on Graphics (Proc. SIGGRAPH 2012)*.
- [21] **The PatchMatch Randomized Matching Algorithm for Image Manipulation.** Connelly Barnes, Dan B Goldman, Eli Shechtman, and Adam Finkelstein. *Invited paper for Communications of the ACM, 54, 11 (Nov. 2011)*. See previous comment in reference [2] about the notability of *Communications of the ACM*.
- [22] **The Generalized PatchMatch Correspondence Algorithm.** Connelly Barnes, Eli Shechtman, Dan B Goldman, and Adam Finkelstein. *European Conference on Computer Vision, Springer (Sept. 2010)*.
- [23] **Video Tapestries with Continuous Temporal Zoom.** Connelly Barnes, Dan B Goldman, Eli Shechtman, and Adam Finkelstein. *ACM Transactions on Graphics (Proc. SIGGRAPH 2010)*.
- [24] **PatchMatch: A Randomized Correspondence Algorithm for Structural Image Editing.** Connelly Barnes, Eli Shechtman, Adam Finkelstein, and Dan B Goldman. *ACM Transactions on Graphics (Proc. SIGGRAPH 2009)*.
- [25] **Video Puppetry: A Performative Interface for Cutout Animation.** Connelly Barnes, David E. Jacobs, Jason Sanders, Dan B Goldman, Szymon Rusinkiewicz, Adam Finkelstein, Maneesh Agrawala. *ACM Transactions on Graphics (Proc. SIGGRAPH Asia 2008)*.
- [26] **Digital Bas-Relief From 3D Scenes.** Tim Weyrich, Jia Deng, Connelly Barnes, Szymon Rusinkiewicz, and Adam Finkelstein. *ACM Transactions on Graphics (Proc. SIGGRAPH 2007)*.
- [27] **Experiential Learning of Design of Experiments Using a Virtual CVD Reactor.** Milo Koretsky, Sho Kimura, Connelly Barnes, Danielle Amatore, and Derek Meyers-Graham. *American Society for Engineering Education Conference 2006*. Award for best paper in chemical engineering.

- [28] **The Virtual CVD Learning Platform.** Milo Koretsky, Danielle Amatore, Connelly Barnes, and Sho Kimura. *Frontiers in Education Conference 2006*.
- [29] **Enhancement of Student Learning in Experimental Design Using a Virtual Laboratory.** Milo Koretsky, Danielle Amatore, Connelly Barnes, and Sho Kimura. *IEEE Transactions on Education 2008*.
- BOOK CHAPTERS
- [30] Created plots, appendices, and educational software ThermoSolver accompanying textbook *Engineering and Chemical Thermodynamics* by Professor Milo Koretsky (2006).
- [31] Co-authored a chapter for *A First Course in Scientific Computing* by Professor Rubin H. Landau (2005).
- THESES
- [32] **PatchMatch: A Fast Randomized Matching Algorithm with Application to Image and Video.** Connelly Barnes. Ph.D. Dissertation, Princeton University, 2011.
- [33] **ThermoSolver: An Integrated Educational Thermodynamics Software Program.** Connelly Barnes. Undergraduate thesis. University Honors College, Oregon State University Library 2006.
- INVITED TALKS
- *In 2016, invited talks at University of Hong Kong, Chinese University of Hong Kong, Hong Kong University of Science and Technology, and the Shandong University summer school at Qingdao campus.*
  - *PatchTable: Efficient Patch Queries for Large Datasets and Applications; and a translating compiler for visual computing in dynamic languages.* University of Southern California, California, USA (November 2015).
  - *Patch-based methods, including PatchTable, which permits efficient patch queries for large datasets.* Shandong University, Department of Computer Science, Jinan, China (August 2015); Tsinghua University, Department of Computer Science, Beijing, China (August 2015).
  - *Patch-based methods: PatchMatch and PatchTable.* INRIA Nancy-Grand Est, Nancy, France (June 2015).
  - *Computer graphics: a bridge between real and virtual worlds.* Talk for high school students. Math Science Innovation Center, Richmond, VA, USA. (March 2015).
  - *Data-driven methods for image manipulation.* Hampden-Sydney College, Virginia, USA (December 2014).
  - Guest lectures: *Patch-based synthesis and Halide autotuning* at the University of Virginia, Computer Science Department, Virginia, USA; NVidia Research, Palo Alto California, USA; Harvard, Computer Science Department, Massachusetts, USA (March 2013).
  - *Patch-based synthesis* lecture at Brown University, Department of Computer Science, Rhode Island, USA (October 2012), University of Washington, Department of Computer Science, Washington USA (March 2011); and Massachusetts Institute of Technology, CSAIL, Massachusetts, USA (March 2011).
- PATENTS
- U.S. Patent 8,285,055, “Determining correspondence between image regions.” Issued: Oct 9, 2012. Assignee: Adobe.
- U.S. Patent 8,407,575, “Video content summary.” Issued: Mar 26, 2013. Assignee: Adobe.
- U.S. Patent 8,571,328, “Determining correspondence between image regions.” Issued: Oct 29, 2013. Assignee: Adobe.
- U.S. Patent 8,625,927, “Image processing using Image Web.” Issued: Jan 7, 2014. Assignee: Adobe.
- U.S. Patent 8,811,749, “Determining correspondence between image regions.” Aug 19, 2014. Assignee: Adobe.

U.S. Patent 8,861,869, “Determining correspondence between image regions.” Oct 14, 2014. Assignee: Adobe.

#### SERVICE

National Science Foundation panelist (2016, 2017).

Program Committee for: CGDIP (2017), Eurographics short papers (2013), Eurographics Symposium on Rendering (2013, 2014, 2017), ICCP (2013), Pacific Graphics (2017), SIGGRAPH (2015, 2016).

Reviewer for: CGF (2010), CHI (2012, 2014), CVPR (2013), ECCV (2012), Eurographics (2010, 2012, 2013, 2014, 2017), ICCV (2013), Pacific Graphics (2013, 2016), IEEE PAMI (2013), SBIM (2010), SIGGRAPH (2010, 2012, 2013), SIGGRAPH Asia (2010, 2012, 2015, 2016), ACM Transactions on Graphics (2014), Transactions on Image Processing (2012, 2013, 2014, 2017), Transactions on Information Forensics and Security (2015), TVCG (2011, 2013, 2016, 2017), UIST (2010, 2011, 2012).

Reviewed Ph.D. dissertations: Michal Lukáč, Czech Technical University in Prague (2016).

#### DIVERSITY

I have supported female students in computer science:

- Yuting Yang, my Ph.D. student from 2015-present.
- Liming Lou, a visiting Ph.D. student from Shandong University to my lab from 2014-2016. Liming will receive her Ph.D. in 2017.
- Olga Diamanti, an intern I supervised while I was at Adobe. Olga received her Ph.D. from ETH Zurich in 2015, and is presently a postdoctoral researcher at Stanford.
- Shanshan He, a supervised masters student at the University of Virginia.

#### TECHNOLOGY TRANSFERS

Two additional technology transfers, aside from the ones associated with my Ph.D. thesis:

- [34] Collaborator Andrew Adams has continued development of the Halide project at Google, where it has been used for “HDR+ on Nexus phones and auto-enhance in Google+ Photos” ([link](#)).
- [35] Collaborator Jingwan Lu has transferred our publication RealBrush into product use at Adobe ([link](#)).

#### PRESS COVERAGE

- [36] **Wired** and **Gizmodo** covered a research project I collaborated on camouflage, and it has 170,000 views on **YouTube**. March 2014.
- [37] **PC Magazine** gave Photoshop content-aware fill a Technical Award in 2010.
- [38] **PatchMatch: The Algorithm Behind Adobe’s CS5 Content Aware Fill in Photoshop**. Princeton University, 2010.
- [39] **Adobe Photoshop CS5: Content-Aware Fill Sneak Peek**, YouTube (5.2 million views). March 2010.
- [40] **Adobe Photoshop CS6 - Content-Aware Fill, Move, Patch**, YouTube (3.4 million views). This is the technical video published with our paper in ACM SIGGRAPH. September 2009.

#### CITIZENSHIP

United States