Arvind Satyanarayan

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EDUCATION

2017 **Ph.D. Computer Science**, Stanford University

Thesis: Declarative Interaction Design for Data Visualization

Advisor: Jeffrey Heer (University of Washington)

2014 M.S. Computer Science, Stanford University

2011 **B.S. Computer Science with Honors**, University of California, San Diego

Thesis: Using Overlays to Support Collaborative Interaction with Display Walls

Advisor: James D. Hollan

EMPLOYMENT

2022– 2018 <i>–</i> 2022	Associate Professor (without tenure), MIT EECS/CSAIL NBX Career Development Assistant Professor, MIT EECS/CSAIL
2017-2018	Postdoctoral Research Scientist, Google Brain Team
2011 – 2017	Graduate Research Assistant , Interactive Data Lab, Stanford University/University of Washington With Prof. Jeffrey Heer
2014 - 2016 2013 - 2014	Co-Founder and Advisor, Apropose, Inc. Co-Founder and Chief Architect, Apropose, Inc. Led initial development of core infrastructure and prototype applications, culminating in a \$1.9M seed investment from NEA and a16z.

AWARDS & HONORS

2022 Significant New Researcher Award, IEEE Visualization & Graphics Technical Committee (VGTC)

MIT Professor Amar G. Bose Research Fellowship

EuroVis Best Paper Honorable Mention (Rich Screen Reader Experiences)

ACM CHI Best Paper Honorable Mention (Shared Interest)

ACM IUI Best Paper Honorable Mention (Embedding Comparator)

2021 MIT Committed to Caring (C2C) Award for Graduate Advising (nominated by students)

MIT EECS Seth J. Teller Award for Excellence, Inclusion and Diversity

Google Research Scholar Award

ACM CHI Best Paper Honorable Mention (Viral Visualizations)

2020 NSF CAREER Award

Kavli Fellow, Kavli Frontiers of Science at the National Academy of Science

Kolokotrones Education Award, MIT EECS

2019 MIT Teaching with Digital Technology Award Nomination (nominated by students)

2016 IEEE InfoVis Best Paper Award (Vega-Lite)

2016 – 2018 Google PhD Fellowship

2015 Kantar Information is Beautiful Awards Shortlist (Lyra)

2013 ACM CHI Best Paper Award (Webzeitgeist)

2011 – 2014 SAP Stanford Graduate Fellowship, Stanford University

2011 Outstanding Senior, UC San Diego Alumni Association

> Phi Beta Kappa, UC San Diego Undergraduate Summer Research Scholar, Calit2, UC San Diego

Ernest Mort Award for Excellence in Leadership, Revelle College, UC San Diego 2009, 2010

Tau Beta Pi, UC San Diego 2009

2010

2008-2010 Provost's Honors, Revelle College, UC San Diego

PEER-REVIEWED PUBLICATIONS

VisText: A Benchmark for Semantically Rich Chart Captioning. Benny J. Tang*, Angie Boggust*, 2023 Arvind Satyanarayan. Proc. Association for Computational Linguistics (ACL), July 2023. Outstanding Paper Award (Top 1.6%).

Saliency Cards: A Framework to Characterize and Compare Saliency Methods. Angle Boggust*, Harini Suresh*, Hendrik Strobelt, John V. Guttag, Arvind Satyanarayan. Proc. ACM Conference on Fairness, Accountability, and Transparency (FAccT), June 2023.

Kaleidoscope: Semantically-Grounded, Context-Specific ML Model Evaluation. Harini Suresh, Divya Shanmugam, Tiffany Chen, Annie Bryan, Alexander D'Amour, John V. Guttag, Arvind Satyanarayan. Proc. ACM Human Factors in Computing Systems (CHI), April 2023.

Deimos: A Grammar of Dynamic Embodied Immersive Visualization Morphs and Transitions. Benjamin Lee, Arvind Satyanarayan, Maxime Cordeil, Arnaud Prouzeau, Bernhard Jenny, Tim Dwyer. Proc. ACM Human Factors in Computing Systems (CHI), April 2023.

Animated Vega-Lite: Unifying Animation with a Grammar of Interactive Graphics. Jonathan Zong*, Josh Pollock*, Dylan Wootton, Arvind Satyanarayan. IEEE Trans. Visualization & Computer Graphics (Proc. IEEE VIS '22), January 2023...

Striking a Balance: Reader Takeaways and Preferences when Integrating Text and Charts. Chase Stokes, Vidya Setlur, Bridget Cogley, Arvind Satyanarayan, Marti Hearst. IEEE Trans. Visualization & Computer Graphics (Proc. IEEE VIS '22), January 2023.

Rich Screen Reader Experiences for Data Visualization. Jonathan Zong*, Crystal Lee*, Alan Lundgard*, JiWoong 2022 Jang, Daniel Hajas, Arvind Satyanarayan. Computer Graphics Forum (Proc. EuroVis '22), June 2022. Best Paper Honorable Mention (2 awarded).

Varv: Reprogrammable Interactive Software as a Declarative Data Structure. Marcel Borowski, Luke Murray, Rolf Bagge, Janus B. Kristensen, Arvind Satyanarayan, Clemens N. Klokmose. Proc. ACM Human Factors in Computing Systems (CHI), May 2022.

Shared Interest: Measuring Human-AI Alignment to Identify Recurring Patterns in Model Behavior. Angie Boggust, Benjamin Hoover, Arvind Satyanarayan, Hendrik Strobelt. Proc. ACM Human Factors in Computing Systems (CHI), May 2022. Best Paper Honorable Mention (Top 5%).

Teaching Humans When To Defer to a Classifier via Exemplars. Hussein Mozannar, Arvind Satyanarayan, David Sontag. Proc. AAAI Conference on Artificial Intelligence (AAAI), March 2022.

Embedding Comparator: Visualizing Differences in Global Structure and Local Neighborhoods via Small Multiples. Angie Boggust*, Brandon Carter*, Arvind Satyanarayan. Proc. ACM Intelligent User Interfaces (IUI), March 2022. Best Paper Honorable Mention (3 awarded).

Intuitively Assessing ML Model Reliability through Example-Based Explanations and Editing Model Inputs. Harini Suresh, Kathleen M Lewis, John V Guttag, Arvind Satyanarayan. Proc. ACM Intelligent User Interfaces (IUI), March 2022.

Accessible Visualization via Natural Language Descriptions: A Four-Level Model of Semantic Content. Alan Lundgard and Arvind Satyanarayan. IEEE Trans. Visualization & Computer Graphics (Proc. IEEE VIS '21), January 2022.

DIEL: Interactive Visualization Beyond the Here and Now. Yifan Wu, Remco Chang, Joseph M. Hellerstein, Arvind Satyanarayan, Eugene Wu. *IEEE Trans. Visualization & Computer Graphics (Proc. IEEE VIS '21)*, January 2022.

Viral Visualizations: How Coronavirus Skeptics Use Orthodox Data Practices to Promote
Unorthodox Science Online. Crystal Lee, Tanya Yang, Gabrielle Inchoco, Graham M Jones, Arvind Satyanarayan.

Proc. ACM Human Factors in Computing Systems (CHI), May 2021. Best Paper Honorable Mention (Top 5%).

Beyond Expertise and Roles: A Framework to Characterize the Stakeholders of Interpretable

Machine Learning and Their Needs. Harini Suresh, Steven R. Gomez, Kevin K. Nam, <u>Arvind Satyanarayan</u>.

Proc. ACM Human Factors in Computing Systems (CHI), May 2021.

Assessing the Impact of Automated Suggestions on Decision Making: Domain Experts Mediate Model Errors but Take Less Initiative. Ariel Levy, Monica Agrawal, <u>Arvind Satyanarayan</u>, David Sontag. *Proc. ACM Human Factors in Computing Systems (CHI)*, May 2021.

Lyra 2: Designing Interactive Visualizations by Demonstration. Jonathan Zong, Dhiraj Barnwal, Rupayan Neogy, <u>Arvind Satyanarayan</u>. *IEEE Trans. Visualization & Computer Graphics (Proc. InfoVis '20)*, February 2021.

B2: Bridging code and Interactive Visualization in Computational Notebooks. Yifan Wu, Joseph M. Hellerstein, Arvind Satyanarayan. *Proc. ACM User Interface Software and Technology (UIST)*, October 2020.

Representing Real-Time Multi-User Collaboration in Visualizations. Rupayan Neogy, Jonathan Zong, Arvind Satyanarayan. *Proc. IEEE Visualization (VIS)*, October 2020.

VisuaLint: Sketchy In Situ Annotation of Chart Construction Errors. Aspen Hopkins, Michael Correll, Arvind Satyanarayan. *Computer Graphics Forum (Proc. EuroVis)*, May 2020.

Critical Reflections on Visualization Authoring Systems. Arvind Satyanarayan, Bongshin Lee, Donghao Ren, Jeffrey Heer, John Stasko, John R. Thompson, Matthew Brehmer, Zhicheng Liu. *IEEE Trans. Visualization & Computer Graphics (Proc. InfoVis* '19), January 2020.

Sociotechnical Considerations for Accessible Visualization Design. Alan Lundgard, Crystal Lee, Arvind Satyanarayan. *Proc. IEEE Visualization (VIS)*, October 2019.

Sherlock: A Deep Learning Approach to Semantic Data Type Detection. Madelon Hulsebos, Kevin Hu, Michiel Bakker, Emanuel Zgraggen, <u>Arvind Satyanarayan</u>, Tim Kraska, Çağatay Demiralp, César Hidalgo. *Proc. ACM Knowledge Discovery and Data Mining (KDD)*, August 2019.

VizNet: Towards a Large-Scale Visualization Learning and Benchmarking Repository. Kevin Hu, Neil Gaikwad, Madelon Hulsebos, Michiel Bakker, Emanuel Zgraggen, César Hidalgo, Tim Kraska, Guoliang Li, <u>Arvind Satyanarayan</u>, Çağatay Demiralp. *Proc. ACM Human Factors in Computing Systems (CHI)*, May 2019.

Altair: Interactive Statistical Visualizations for Python. Jacob VanderPlas, Brian E. Granger, Jeffrey Heer, Dominik Moritz, Kanit Wongsuphasawat, <u>Arvind Satyanarayan</u>, Eitan Lees, Ilia Timofeev, Ben Welsh, Scott Sievert. *Journal of Open Source Software* 3(32), October 2018.

Augmenting Code with In Situ Visualizations to Aid Program Understanding. Jane Hoffswell, Arvind Satyanarayan, Jeffrey Heer. *Proc. ACM Human Factors in Computing Systems (CHI)*, April 2018.

The Building Blocks of Interpretability. Chris Olah, <u>Arvind Satyanarayan</u>, lan Johnson, Shan Carter, Ludwig Schubert, Katherine Ye, Alexander Mordvintsev. *Distill* 3(3), March 2018.

- Vega-Lite: A Grammar of Interactive Graphics. Arvind Satyanarayan, Dominik Moritz,
 Kanit Wongsuphasawat, Jeffrey Heer. IEEE Trans. Visualization & Computer Graphics (Proc. InfoVis '16),
 January 2017. Best Paper Award (1 Annually).
- Visual Debugging Techniques for Reactive Data Visualization. Jane Hoffswell, <u>Arvind Satyanarayan</u>, Jeffrey Heer. Computer Graphics Forum (Proc. EuroVis), June 2016.

Reactive Vega: A Streaming Dataflow Architecture for Declarative Interactive Visualization.

<u>Arvind Satyanarayan</u>, Ryan Russell, Jane Hoffwell, Jeffrey Heer. *IEEE Trans. Visualization & Computer Graphics (Proc. InfoVis '15)*, January 2016.

Declarative Interaction Design for Data Visualization. Arvind Satyanarayan, Kanit Wongsuphasawat, Jeffrey Heer. Proc. ACM User Interface Software and Technology (UIST), October 2014.

Lyra: An Interactive Visualization Design Environment. Arvind Satyanarayan, Jeffrey Heer. *Computer Graphics Forum (Proc. EuroVis)*, June 2014.

Authoring Narrative Visualizations with Ellipsis. <u>Arvind Satyanarayan</u>, Jeffrey Heer. *Computer Graphics Forum (Proc. EuroVis)*, June 2014.

- Webzeitgeist: Design Mining the Web. Ranjitha Kumar, Arvind Satyanarayan, Cesar Torres, Maxine Lim, Salman Ahmad, Scott R. Klemmer, Jerry O. Talton. Proc. ACM Human Factors in Computing Systems (CHI), May 2013. Best Paper Award (Top 1%).
- Using Overlays to Support Collaborative Interaction with Display Walls. Arvind Satyanarayan, Nadir Weibel, James D. Hollan. *Proc. ACM Intelligent User Interfaces (IUI)*, February 2012.

PRE-PRINTS

The Effectiveness of Haptic Properties Under Cognitive Load: An Exploratory Study. Nava Haghighi, Nathalie Vladis, Yuanbo Liu, Arvind Satyanarayan. *arXiv*:2006.00372, May 2020.

WORKSHOP & POSITION PAPERS, POSTERS & REPORTS

Shared Interest: Human Annotations vs. Al Saliency. Angie Boggust, Benjamin Hoover, Arvind Satyanarayan, Hendrik Strobelt. VISxAI, October 2020.

Towards a Dynamic Multiscale Personalized Information Space. James Hollan, Amy Fox, Philip Guo, Clemens Klokmose, Arvind Satyanarayan, Haijun Xia. *Convivial Computing Salon*, <*Programming>*, May 2020.

Self-Interfaces: Utilizing Real-Time Biofeedback in the Wild to Elicit Subconscious Behavior Change.Nava Haghighi, <u>Arvind Satyanarayan.</u> *Work-in-Progress of ACM Tangible and Embodied Interaction (TEI)*February 2020.

- Visualive: Representing Synchronized Visualization Interactions. Rupayan Neogy, Emily Hu, Arvind Satyanarayan. Posters of IEEE Visualization (VIS), October 2019.
- Designing Cognitively Convivial Physics for Dynamic Visual Information Substrates.

 James D. Hollan, <u>Arvind Satyanarayan</u>. Rethinking Interaction Workshop, ACM Human Factors in Computing Systems (CHI), May 2018.

The CHI 2013 Interactive Schedule. Arvind Satyanarayan, Daniel Strazzulla, Clemens Klokmose, 2013 Michel Beaudouin-Lafon, Wendy Mackay. Extended Abstracts, ACM Human Factors in Computing Systems (CHI), May 2013. 2012 **Learning Structural Semantics for the Web.** Maxine Lim, Ranjitha Kumar, Arvind Satyanarayan, Cesar Torres, Jerry O. Talton, Scott R. Klemmer. Stanford CSTR 2012-03, December 2012. A Platform for Large-Scale Machine Learning on Web Design. Arvind Satyanarayan, Maxine Lim, Scott R. Klemmer. Extended Abstracts, ACM Human Factors in Computing Systems (CHI), May 2012 **INVITED TALKS & DEMOS** Model Saliency is an Abstraction of Model Behavior June 2023 Invited Talk, Explainable AI for Computer Vision Workshop, CVPR 2023 Intelligence Augmentation through the Lens of Interactive Data Visualization April 2023 Stanford University, Stanford, CA April 2023 University of Maryland, College Park, MD April 2023 Columbia University, New York, NY Towards Effective Interaction with Data Visualization March 2022 All India Council on Technical Education (AICTE) Nov 2021 Sigma Computing Symposium on Data Science & Statistics, American Statistics Association Jun 2020 Keynote Talk, Workshop on Human-In-the-Loop Data Analytics, ACM SIGMOD 2020 From Tools to Toolkits: Towards more Reusable, Composable, and Reliable Machine Learning Interpretability Keynote Talk, Visualization in Data Science (VDS) Workshop, ACM KDD 2021 Aug 2021 Visualization for Machine Learning Jun 2021 Information Science Institute, University of Southern California Apr 2021 Daimler/Mercedes-Benz AI Visualization: A Petri Dish for Intelligence Augmentation Apr 2019 Radcliffe Institute for Advanced Study, Harvard University, Cambridge, MA Oct 2018 MIT CSAIL, Cambridge, MA Sep 2018 Northeastern University, Boston, MA The Building Blocks of Interpretability May 2018 emlyon business school, Lyon, France Vega-Lite: A Grammar of Interactive Graphics Apr 2017 OpenVis Conf, Boston, MA Declarative Interaction Design for Data Visualization Massachusetts Institute of Technology, Cambridge, MA Apr 2017 New York University, Tandon Computer Science & Center of Data Science, New York City, NY University of California, San Diego, San Diego, CA Northwestern University, Evanston, IL

Cornell University, Computer Science & Information Science, Ithaca, NY

University of British Columbia, Vancouver, Canada

University of California, Berkeley, Berkeley, CA University of Illinois Urbana-Champaign, Urbana, IL

University of Wisconsin-Madison, Madison, WI

University of Toronto, Toronto, Canada University of Michigan, Ann Arbor, MI

Mar 2017

Feb 2017

The Vega Ecosystem Oct 2016 Keynote Talk, Visualization In Practice Workshop, IEEE VIS, Baltimore, MD Reactive Building Blocks: Interactive Visualizations with Vega Jul 2016 Keynote Talk, DataViz Camp, United Nations OpenVis Conf, Boston, MA Apr 2016 Higher-Level Tools for Interactive Data Visualization May 2016 INRIA Saclay, Saclay, France Sep 2015 BiD Seminar, UC Berkeley, Berkeley, CA Lowering the Threshold of Visualization Design Apr 2015 Linfield College, Science Colloquium, McMinnville, OR Dec 2014 Tata Innovation Labs, Tata Consultancy Services, Delhi, India Designing Visualizations with Lyra Tutorial Apr 2015 1247: Information Visualization & Presentation, UC Berkeley Information School, Berkeley, CA Dec 2014 Tata Innovation Labs, Tata Consultancy Services, Delhi, India J221: Introduction to Data Visualization, UC Berkeley Journalism School, Berkeley, CA HCDE 511: Information Visualization, University of Washington, Seattle, WA Nov 2014 Lyra: An Interactive Visualization Design Environment Apr 2014 OpenVis Conf, Boston, MA Mar 2014 CAR, Baltimore, MD Feb 2014 Tapestry, Annapolis, MD NewsCamp:: Introduction to D3 Mar 2014 CAR, Baltimore, MD **TEACHING** 6.859: Interactive Data Visualization, MIT EECS 2019 -6.859: Interactive Data Visualization, MIT EECS 2019 -(Numbered 6.894 in 2019 and 2020) 2018 -6.170: Software Studio, MIT EECS Co-Instructor with Prof. Daniel Jackson Winter 2016 HCID 520: User Interface Software & Technology, University of Washington Co-Instructor with Prof. Jeffrey Heer Winter 2013 CS 247: Human-Computer Interaction Design Studio, Stanford University Graduate Teaching Assistant for Profs. Jeffrey Heer and Michael Bernstein Fall 2012 CS 147: Introduction to Human-Computer Interaction, Stanford University Graduate Teaching Assistant for Prof. Scott Klemmer HCI Online #001, Stanford University and Coursera Winter 2012 Graduate Teaching Assistant for Prof. Scott Klemmer **ADVISEES Postdocs** Amy Rae Fox, Vineet Pandey

6 of 8

Angie Boggust (EECS), Crystal Lee (STS '22, co-advised w/Graham Jones), Josh Pollock (EECS), Harini Suresh (EECS '23, co-advised w/John Guttag), Dylan Wootton (EECS), Jonathan Zong (EECS)

PhD

Alan Lundgard (EECS '20), Ben Tang (ID&M '21), Katherine Bacher (EECS '21), Nava Haghighi (ID&M '20), Master's

Houssam Kherraz (EECS '20), Rupayan Neogy (EECS '20), Ebenezer Sefah (EECS '21), Wonyoung So (DUSP '20)

Undergraduate Anna Arpaci-Dusseau (EECS '23), Soomin Chun (EECS & Math '22), Dhiraj Kumar (IIT Kharagpur '20),

Katherine Huang (CMS & EECS '23), Allen Lee (EECS '20), Anna Meurer (MechE '23),

Mateo Monterde (Math & Management '23), Ethan Nevidomsky (CMS & EECS '22), Tanya Yang (EECS '22)

Mentoring as a PhD Student

Tianyi "Tina" Lin (UW CSE '17), Matthew Chun (UW CSE '18), Yiyang "Amy" Xu (UW CSE '18),

Anjir Hossain (UW CSE'18), Nikhil Khanna (UW CSE'18), Emily Gu (UW CSE'16),

Ruijia "Iris" Wang (UW CSE '17), Ryan Russell (UW CSE '16)

SERVICE

Reviewing IEEE VIS 2014-2020, EuroVis 2014-2021, IEEE TVCG 2015-2021, ACM UIST 2014-2020,

ACM CHI 2013-2021, ACM IUI 2012-2021, IEEE PacificVis 2016.

Recognition for exceptional reviews: UIST 2020, CHI 2019, CHI 2017, VIS 2017 (x2).

Diversity & Inclusivity. MIT EECS 2019—Present. IEEE VIS 2018–2020, Information+2018. Committees

Program Committees. ACM IUI 2019–2021, IEEE VIS 2018–2020, OpenVis Conf 2016–2018,

ACM CHI 2016 Late-Breaking Work, Information+ 2018, 2021.

Publications Co-Chair, IEEE VIS 2021, 2022 2021, 2022

Distill (http://distill.pub) Co-Editor. 2018-2020

Diversity & Inclusion Co-Chair, IEEE VIS 2019, 2020 2019, 2020

2018 Program Co-Chair, OpenVis Conf

Interactive Schedule Chair, CHI 2013 Organizing Committee 2013

2008 - 2011 **Undergraduate Student Leadership**, UC San Diego.

> 2009 - 2011 Resident Advisor, Revelle College

Student Conduct Code Re-write Workgroup Student Representative 2010 - 2011 Housing, Dining, Hospitality Advisory Committee Student Representative 2010 - 2011

Parent Orientation Leader, Revelle College Summer 2010 2009-2010 Revelle College Senator, Associated Students

2008-2009 Director of Communications, Revelle College Council

PRESS

Fifteen MIT faculty honored as "Committed to Caring" for 2021-23. 2021

Daniel Korsun, MIT News, October 2021

https://news.mit.edu/2021/fifteen-mit-faculty-honored-committed-caring-1022

When more Covid-19 data doesn't equal more understanding.

Daniel Ackerman, MIT News, March 2021

https://news.mit.edu/2021/when-more-covid-data-doesnt-equal-more-understanding-0304

3Q: Collaborating with users to develop accessible designs. 2020

Rob Matheson, MIT News, March 2020

http://news.mit.edu/2020/accessible-designs-data%20visualization-0313

Google Researchers Are Learning How Machines Learn. 2018

Cade Metz, The New York Times, March 2018

https://www.nytimes.com/2018/03/06/technology/google-artificial-intelligence.html

2014 Apropose Closes \$1.875M Funding Round Led by NEA and Andreessen Horowitz.

PR Newswire, September 2014

http://www.prnewswire.com/news-releases/apropose-closes-1875m-funding-round-led-by-nea-and-andreessen-horowitz-274728751.html

10 Significant Visualization Developments: January to June 2014.

Andy Kirk, Visualizing Data, August 2014

http://www.visualisingdata.com/index.php/2014/08/10-significant-visualisation-developments-january-to-june-2014/

2008 Movable Type Experts Team Up on Melody, an Open Source Publishing Platform.

Techcrunch, June 2009

http://techcrunch.com/2009/06/25/movable-type-experts-team-up-on-melody-an-open-source-publishing-platform/

2007 Why We Call it a "Community".

Anil Dash, Six Apart/Movable Type, August 2007

http://www.movabletype.com/blog/2007/02/why-we-call-it-a-community.html