

S. Sandra Bae

ATLAS Institute
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RESEARCH INTEREST

My research spans across human-computer interaction (HCI), data visualization, and computational fabrication. I study the interplay of the digital and physical worlds when people analyze high-dimensional and spatial data.

I specifically focus on uncovering the analytical contexts—whether they're *user-driven* or *data-driven*—of when data representations and interactions should be beyond the traditional desktop setup. To investigate this question, I situate my work in various domains, such as aerodynamics, robotics, network science, literacy, and design. My research activities include introducing theoretical frameworks, conducting empirical and qualitative studies, and building systematic toolkits (algorithms and hardware design).

Keywords: Human-Computer Interaction, Data Visualization, Computational Geometry & Fabrication, Optimization, Tangible Interactions

Last Updated (Nov 2024)

EDUCATION

2020 - PRESENT	University of Colorado, Boulder <i>Ph.D. in Creative Technology & Design</i> Advisor: Ellen Do, Danielle Szafir, & Michael Rivera ACME Lab, VisuaLab, & Utility Lab
2018 - 2020	University of California, Davis <i>M.S. in Computer Science</i> Advisor: Kwan-Liu Ma ViDi Lab
2014 - 2018	University of California, Davis <i>B.A. in Human-Computer Interaction</i> <i>Minor in Education</i>

AWARDS AND DISTINCTION

2024	APUP Researcher at the National Renewable Energy Laboratory (\$230,000) *
2024	KASF-KIA Scholarship (\$2,500) (Top 5 recipient for KIA special recognition for excellence in STEM) *
2024	CU Boulder's Special Recognition Award for Partnership for Sustainability (<i>Coffee Ground Filament</i>)
2023	EECS Rising Star *
2023	Best Paper Honorable Mention (IEEE VIS23) *
2023	Korean American Scholarship Foundation (\$2,000)
2023	Achievement Reward for College Scientists (\$7,500)
2023	Rocky Mountain RepRap Festival, Most Functional/Useful, Sensing Networks *
2023	Rocky Mountain RepRap Festival, Most Innovative, <i>Coffee Ground Filament</i>
2022	Achievement Reward for College Scientists (\$7,500)
2022	Korean American Scholarship Foundation (\$3,000)
2022	David T. Spalding Graduate Teaching Fund Fellowship (\$1000)
2021	Korean American Scholarship Foundation (\$2,000)
2021	CU Boulder Travel Grant (\$500)
2021	CU Boulder Dean's Engineering Travel Grant (\$400)
2021	Honorable Mention, IEEE World Haptics Student Design Competition
2021	CRA-WP Grad Cohort for Women
2021	Ada Lovelace Fellow, Open Hardware Summit
2021	Craft Award, ACM TEI Student Design Competition.

2021 Achievement Reward for College Scientists (\$6,500)
2019 Richard C. and Joy Dorf Engineering Graduate Fellowship (\$1,000)
2019 NASA JPL Master's Thesis Educational Fellow (\$30,000) *
2018 NSF's Preparing Engineering Graduate Students for the 21st Century Fellow (\$10,000).
2018 Honorable Mention Visual Storytelling Award, IEEE Pacific Visualization Symposium.
2017 Beneath (CONNECT EXPO 2017) - Judge's Honorable Mention.
2017 UC Davis Organizational Research Expo.
2017 Better Together - AIGA and IDSA.

FUNDING

UNDER REVIEW

Tactile Perception of Surface Roughness for 3D Printed-Textures: Theory and Application for Data Visualization
Amount: \$2,500
Agency: Sigma Xi (The Scientific Research Honor Society)
Principal Investigator: S.Sandra Bae, CU Boulder
Submitted: Oct 2024

CONTRIBUTED TO AWARDED GRANTS (TOTAL \$561K)

Human-Computer Interaction Techniques for Large-Scale Data Analysis
Amount: \$231,000
Agency: Alliance Partner University Program (APUP) with National Renewable Energy Laboratory (NREL)
Principal Investigator: Michael L. Rivera, CU Boulder
Co-Principal Investigator: Kenny Gruchulla, NREL
Duration: Jan 2024 - May 2025
Contribution: Wrote 25% for one of three research activities to be executed in conjunction at NREL.

Supporting Explainable AI for Future Analysts with Interactive Physicalizations
Amount: \$30,000
Agency: CU Boulder Seed Grant (Engineering Education and AI-Augmented IRT)
Principal Investigator: Michael L. Rivera, CU Boulder
Co-Principal Investigator: Ellen Yi-Luen Do, CU Boulder
External Co-Principal Investigator: Danielle Albers Szafir, UNC-Chapel Hill
Duration: Sept 2023 - Dec 2023
Contribution: Wrote one of two research threads, including introduction and research assessment, where we promote a hybrid analytical environment using tangible objects to support AI explainability.

EAGER: Home-Based DIY Interactive Information Physicalization for Young Children and their Parents
Amount: \$300,000
Agency: National Science Foundation
Principal Investigator: Ellen Yi-Luen Do, CU Boulder
Co-Principal Investigator: Danielle Albers Szafir, CU Boulder
Duration: Oct 2020 - Sep 2022
Contribution: Wrote two of the three research threads, including the background and research plan, where we will develop an informal, home-based approach to promote data visualization literacy for young children.

RESEARCH EXPERIENCE

- WINTER 2024 -
PRESENT **National Renewable Energy Lab (NREL) | Golden, CO**
Graduate Research Assistant
Research with Kenny Gruchalla, Olga Doronina, and Ryan King.
Developing an analytical tangible user interface to manipulate affine transformations for aerodynamic design (e.g., wind blades). In collaboration with NIST (Dr. Zachary Grey).
- FALL 2020 -
PRESENT **University of Colorado, Boulder | Boulder, CO**
Graduate Research Assistant & Teaching Assistant
Research with Danielle Albers Szafir, Ellen Yi-Luen Do, and Michael L. Rivera.
Teaching assistant for Daniel Leithinger, Laura Devendorf in ATLAS.
- SUMMER 2020 **Stanford University | Palo Alto, CA (Remote)**
HCI Research Intern
Research with James Landay and Elizabeth Murnane.
Identifying and building family-centered, in-car technology to support collaborative learning.
- SUMMER 2019 -
SUMMER 2020 **NASA Jet Propulsion Lab | Pasadena, CA**
University Researcher
Research with Federico Rossi, Scott Davidoff, and Joshua Vander Hook.
Working as a NASA JPL Master's Thesis Fellow to expand Summer 2019's project.
- SUMMER 2019 **NASA Jet Propulsion Lab | Pasadena, CA**
Data Visualization / HCI Research Intern
Research with Hillary Mushkin, Santiago Lambledya, Maggie Hendrie, Scott Davidoff.
Developed a visual analytics systems to analyze scheduling coordination for multi-robot systems
- SUMMER 2019 -
SPRING 2020 **University of California, Davis | Davis, CA**
Undergraduate / Graduate Student Research Assistant & Teaching Assistant
Research with Kwan-Liu Ma.
Teaching assistant for Kwan-Liu Ma, Hao-Chuan Wang, and Nina Amenta in Computer Science.

REFEREED PUBLICATIONS

I author in both **computer science** and **physical science** venues. For *physical sciences*, I author in journals, such as the Journal of Astronautical Sciences . In *computer science*, conferences are the primary venues (~25% acceptance rates). I author in ACM CHI Conference on Human Factors in Computing Systems (CHI), the ACM conference on Designing Interactive Systems (DIS), IEEE Visualization Conference (IEEE VIS), and IEEE International Conference on Robotics and Automation (IEEE ICRA).

JOURNAL ARTICLES

- J1 S. S. Bae, T. Fujiwara, A. Ynnerman, E. Y.-L. Do, M. Rivera, and D. A. Szafir. "A Computational Design Pipeline to Fabricate Sensing Network Physicalizations". In: *IEEE Transactions on Visualization and Computer Graphics (also proc. IEEE VIS 2023)*. Melbourne, Australia, 2023, Acceptance rate: 24.7% (133/539)
* **Best Paper Honorable Mention (Top 5%)**.
- J2 S. S. Bae, R. Vanukuru, R. Yang, P. Gyory, R. Zhou, E. Y.-L. Do, and D. A. Szafir. "Cultivating Visualization Literacy for Children Through Curiosity and Play". In: *IEEE Transactions on Visualization and Computer Graphics (also proc. IEEE VIS 2022)*. 2022, Acceptance rate: 26.5% (122/460).
- J3 R. Woollands, F. Rossi, T. S. Vaquero, M. S. Net, S. S. Bae, V. Bickel, and J. V. Hook. "Maximizing Dust Devil Follow-Up Observations on Mars Using Cubesats and On-board Scheduling". In: *Journal of Astronautical Sciences*. 2022.

CONFERENCE ARTICLES

- C1 R. Sorenson-Graff, S. S. Bae, and J. Wirfs-Brock. “Integrating Annotations for Sonifications and Physicalizations”. In: *Proceedings of the IEEE VIS 2024*. St. Pete Beach, Florida, 2024, Acceptance rate: 31.9% (66/207).
- C2 P. Gyory, S. S. Bae, R. Yang, E. Y.-L. Do, and C. Zheng. “Marking Material Interactions with Computer Vision”. In: *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*. Hamburg, Germany, 2023, Acceptance rate: 28.39% (880/3182).
- C3 M. Rivera, S. S. Bae, and S. Hudson. “Exploring Spent Coffee Grounds as a Sustainable Material for Prototyping with 3D Printing”. In: *Proceedings of the 2023 on Designing Interactive Systems Conference*. Pittsburg, PA, USA, 2023, Acceptance rate: 24.1% (174/726).
- C4 S. S. Bae, D. A. Szafer, and E. Y.-L. Do. “Exploring the Benefits and Challenges of Data Physicalization”. In: *Proceedings of the Fourth European Tangible Interaction Studio (ETIS’ 22)*. Toulouse, France, 2022, Acceptance rate: 88% (15/17).
- C5 S. S. Bae, C. Zheng, M. E. West, E. Y.-L. Do, S. Huron, and D. A. Szafer. “Making Data Tangible: A Cross-disciplinary Design Space for Data Physicalization”. In: *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*. New Orleans, Louisiana, 2022, Acceptance rate: 23% (4590/19964).
- C6 S. S. Bae, F. Rossi, J. V. Hook, S. Davidoff, and K.-L. Ma. “A Visual Analytics Approach to Debugging Cooperative, Autonomous Multi-Robot Systems’ Worldviews”. In: *Proceedings of the IEEE Visual Analytics Science and Technology (VAST) 2020*. Salt Lake City, Utah (Virtual), 2020, Acceptance rate: 24.8% (52/210).
- C7 S. S. Bae*, O.-H. Kwon*, S. Chandrasegaran, and K.-L. Ma. “Spinneret: Aiding Creative Ideation through Non-Obvious Concept Associations”. In: *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. Honolulu, Hawaii (Virtual), 2020, (*equally contributed), Acceptance rate: 24.31% (760/3126).

DEMOS & POSTERS

- D1 S. S. Bae, T. Fujiwara, D. A. Szafer, E. Y.-L. Do, and M. L. Rivera. “3D printed multi-point capacitive touch sensor”. In: *Symposium on Computational Fabrication*. SCF ’24. Aarhus, Denmark: Association for Computing Machinery, 2024.
- D2 E. Johnson, S. S. Bae, and E. Y.-L. Do. “Supporting Data Visualization Literacy through Embodied Interactions”. In: *Proceedings of the Fifteenth International Conference on Creativity & Cognition (C&C’22)*. Gather-town (Remote): Association for Computing Machinery, 2023.
- D3 S. S. Bae. “Towards a Deeper Understanding of Data and Materiality”. In: *Proceedings of the Fourteenth International Conference on Creativity & Cognition (C&C’22)*. Venice, Italy: Association for Computing Machinery, 2022.
- D4 S. S. Bae, R. Yang, P. Gyory, J. Uhr, D. A. Szafer, and E. Y.-L. Do. “Touching Information with DIY Paper Charts & AR Markers”. In: *Interaction Design and Children*. IDC ’21. Athens, Greece (Virtual): Association for Computing Machinery, 2021, Acceptance rate: 27% (136/501).
- D5 S. S. Bae* and M. E. West*. “Cyborg Crafts: Second SKIN (Soft Keen INteraction)”. In: *Proceedings of the Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI’21)*. Salzburg, Austria (Virtual): Association for Computing Machinery, 2021, (*equally contributed).

TECH REPORTS

- T1 R. Woollands, F. Rossi, T. S. Vaquero, M. S. Net, S. S. Bae, V. Bickel, and J. V. Hook. “Maximizing Dust Devil Follow-Up Observations on Mars Using Cubesats and On-board Scheduling”. In: *Proceedings of the 43rd Annual AAS Guidance & Control Conference, Breckenridge, CO*. 2021.

BOOK CHAPTERS

- B1 T. Hopkins, S. S. Bae, J. Uhr, C. Zheng, A. Banic, and E. Y.-L. Do. “User Interfaces in Smart Cities”. In: *Handbook of Smart Cities*. Ed. by J. C. Augusto. Springer International Publishing, 2021.

PATENT AND INDUSTRY PARTNERSHIP

NON-PROVISIONAL PATENT APPLICATION

Bae, S. S, Fujiwara, T., Rivera, M.L., Szafir, D.A., Do., E.Y.D (2023). Systems and Methods for Touching Sensing Based on Resistor-Capacitor Delays. *U.S. Patent Application 63/497,594*, filed April 21, 2023. Pending non-provisional patent application.

INDUSTRY PARTNERSHIP

Company	Funding	Year
Stratasys	Gift	2024
Protopasta	Sponsored Research	2024

TALKS

All first-author conference papers listed above were also given as presentations at their respective conferences and are not listed again in this section.

INVITED GUEST LECTURER

Expanding your Interactive Toolkit: Computer Vision Markers and 3D Printed Capacitive Sensors

Georgia Tech, *Prototyping Interactive Systems*, November 7, 2023 (hosted by Hyunjoo Oh)

Using Computational Fabrication for Data Physicalization

UNC-Chapel Hill, *Information Professionals in the Makerspace*, October 17, 2023 (hosted by Maggie Melo)

Computational Fabrication for Electronics

CU Boulder, *Computational Fabrication*, October 16, 2023 (hosted by Michael L. Rivera)

The Value of Design: Empowering Humans through Human-Centered Thinking

CU Boulder, *Information Visualization*, March 18, 2021 (hosted by Danielle Szafir)

The Value of Design: Empowering Humans through Human-Centered Thinking

UC Davis, *Android Development*, January 14, 2021 (hosted by Nina Amenta)

INVITED TALKS

Lifting Visualizations Beyond Flatland: A Geometric Perspective

National Institute of Science and Technology (NIST), October 1, 2024 (hosted by Matt Whitlock)

Pushing Visualizations Beyond the Desktop with Everyday Devices and Novel Interfaces

University of Iowa, November 17, 2023 (hosted by Juan Pablo Hourcade)

Pushing Visualizations Beyond the Desktop with Everyday Devices and Novel Interfaces

Emory University, November 8, 2023 (hosted by Emily Wall)

Pushing Visualizations Beyond the Desktop with Everyday Devices and Novel Interfaces

Georgia Tech, November 8, 2023 (hosted by Yalong Yang)

Using Network Science to Reimagine Everyday Objects as Future Computers

TTI Vanguard, September 13, 2023 (hosted by Nancy Kleinrock)

Towards “Best of Both Worlds”: Bridging Digital and Physical Representations in Visualization Research

Linköping University, January 9, 2023 (hosted by Miriah Meyer)

Debugging Multi-Robot Autonomous System Anomalies

CU Boulder ATLAS Seminar, October 6, 2020 (hosted by Ellen Yi-Luen Do)

Debugging Multi-Robot Autonomous System Anomalies

NASA-JPL, August 27, 2020 (hosted by Scott Davidoff)

TEACHING AND MENTORING

TEACHING EXPERIENCE

** indicates the instructor of the course*

Term	Institute	Subject Title	Role	Enrolled	Evals
SUMMER 2024	MIT	Web Development (Brave Behind Bars ¹)	Teaching assistance Thomer Gil*	54	No
SPRING 2022	CU Boulder	ATLAS3300: Object (Physical Computing)	Teaching assistance Laura Devendorf*	37	No
SPRING 2021	CU Boulder	ATLAS3300: Object (Physical Computing)	Teaching assistance Daniel Leithinger*	36	No
SPRING 2020	UC Davis	ECS162: Web Programming	Teaching assistance Nina Amenta*	122	Yes
WINTER 2020	UC Davis	ECS164: Intro to Human-Computer Interaction	Teaching assistance Hao-Chuan Wang*	59	Yes
WINTER 2019	UC Davis	ECS164: Intro to Human-Computer Interaction	Teaching assistance Hao-Chuan Wang*	63	Yes
SUMMER 2018	UC Davis	ECS163: Information Visualization	Teaching assistance Kwan-Liu Ma*	23	No

MENTORING

Name	Degree	Year	Context
Quintan Gerhardstein	M.S. in Creative, Tech. & Design (CU Boulder)	2024	Master's thesis
Krithik Ranjan	Ph.D. in Creative, Tech. & Design (CU Boulder)	2024	Research project [R6]
Xin Wen	Ph.D. in Creative, Tech. & Design (CU Boulder)	2024	Research project [R8]
Chin Tseng	Ph.D in Computer Science (UNC-Chapel Hill)	2023–2024	Research project [R3]
Carson Kohlbrenner	M.S. in Aerospace Engineering (CU Boulder)	2023–2024	Research project [R4]
Rhys Sorenson-Graff	B.A. in Computer Science (Whitmann College)	2023–2024	Research project [C1]
Peter Gyory	Ph.D. in Creative, Tech. & Design (CU Boulder)	2022–2023	Research project [C2]
Elise Johnson	B.S. in Mechanical Engineering (CU Boulder)	2021–2022	Research project [D2]
Alex Dickhans	High school student	2024	Research project [R4]
Ruhan Yang	Ph.D. in Creative, Tech. & Design (CU Boulder)	2024	Research project
Ada Zhao	M.S. in Creative, Tech. & Design (CU Boulder)	2024	Research project

¹Brave Behind Bars is a college-accredited introductory computer science and career-readiness program for incarcerated people.
<https://bravebehindbars.org/>

Noah Liska	B.S. in Computer Science (CU Boulder)	2023–2024	Research project
Caleb Kumar	B.S. in Computer Science (CU Boulder)	2023–2024	Research project
Eloise Yalovitser	B.F.A in Design & Tech. (Parson School of Design)	2023	Research project
Antonio (Zhixing) Li	B.S. in Mechanical Engineering (CU Boulder)	2023	Research project
Vy Thai	B.S. in Computer Science (Stanford University)	2020	Research project
Ashleigh Thomas	M.S. in Computer Science (UC Davis)	2019	Department mentorship
Lovpret Kaur	B.S. in Computer Science (UC Davis)	2019	Department mentorship

ACADEMIC SERVICE

Program Committee

ACM Creativity & Cognition 2021

ACM Tangible and Embedded Interaction (TEI) 2024

Organizing Committee

IEEE VIS 2022, 2024 BELIV Workshop (Social Media and Web Chair)

Invited Conference Reviewer

ACM Symposium on User Interface Software and Technology (UIST) 2021

ACM Interaction Design and Children (IDC) 2023

ACM Designing Interactive Systems (DIS) 2021–2024

ACM Conference on Human Factors in Computing Systems (CHI) 2021–2025

ACM Tangible and Embedded Interaction (TEI) 2022–2025

ACM Creative & Cognition (CC) 2021–2022

EG/VGTC EuroVis 2022

NordicCHI 2024

SIGGRAPH Asia Technical Paper 2024

IEEE VR 2025

Invited Journal Reviewer

IEEE Transactions on Visualization and Computer Graphics (TVCG) 2022–2024

International Journal of Child-Computer Interaction 2022

Behaviour & Information Technology 2023, 2024

IS&T Journal of Perceptual Imaging 2024, 2025

Invited Book Chapter Reviewer

“Visualization Psychology” published by Springer Nature. Editors: Danielle Albers Szafir, Rita Borgo, Min Chen, Darren J. Edwards, Brian Fisher, & Lace Padilla

Special Recognition as a Reviewer

2023 ACM Tangible and Embedded Interaction (TEI)

2023 ACM Conference on Human Factors in Computing Systems (CHI) x2

2024 ACM Conference on Human Factors in Computing Systems (CHI) x2

Institutional Service

Ph.D. Open House Organizer 2021, ATLAS Institute, CU Boulder

Faculty Candidate Student Host 2021, 2024 ATLAS Institute, CU Boulder

Ph.D. Graduate Application Support Program Founder 2022, 2023, ATLAS Institute, CU Boulder

Tutoring

Coding tutor, Women’s Resources and Research Center UC Davis, UC Davis (2016–2018)

DESIGN EXHIBITIONS

2019 Sit On Data | Imagining America's 20th Anniversary National Gathering

A data-driven parametric-bench where users can feel the data by sitting. Developing using Python, CNC routing, Laser cutting.

2017 BENEATH | SOFA Chicago 2017

An immersive installation conveying California's land subsidence. Presented at SOFA Chicago 2017. Built motion graphics and projection using Processing.

2017 OneClimate: Prototyping Climate Change | Exploratorium Museum (SF)

A multisensory exhibition conveying the impact of climate change sponsored by the John Muir Institute of the Environment. Featured at the Exploratorium in San Francisco for the OneClimate event, AIGA & ISAD - San Francisco, and IA's 2017 National Gathering. Designed the scientific narrative and constructed the exhibit using woodshop skills.

SELECTED MEDIA COVERAGE

2023 Yahoo Finance | First-of-its-kind study combines common household waste product with 3D printing — here are the results

<https://finance.yahoo.com/news/first-kind-study-combines-common>

2023 Ars Technica | Don't throw out those used coffee grounds—use them for 3D printing instead

<https://arstechnica.com/science/2023/09/dont-throw-out-those-used-coffee-grounds-use-them-for-3d-printing-instead/>

2023 TechBriefs | Using Coffee to Reduce Waste from 3D Printing

<https://www.techbriefs.com/component/content/article/tb/stories/blog/49103>

2023 Daily camera (Boulder) | CU Boulder professor creates 3D printing paste with coffee grounds

<https://www.dailycamera.com/2023/09/20/cu-boulder-professor-creates-3d-printing-paste-with-coffee-grounds/>

2023 CNC Kitchen (Youtube) | 3D Printing Resistors, Fibers & Coffee - Utility Research Lab

https://youtu.be/Oeqvo2c28_c

2023 Make Magazine | Rocky Mountain RepRap Fest: All The Cool 3D Printing Stuff

<https://makezine.com/article/digital-fabrication/3d-printing-workshop/3d-printing-festival-loveland-colorado/>

2023 Meltzone Podcast | Rocky Mountain RepRap Festival & Prusa MK4

<https://youtu.be/NkgOXFn55cM?t=1041>

2023 CU Boulder | ATLAS Innovators Win Big at RepRap Festival

<https://www.colorado.edu/atlas/2023/05/08/atlas-innovators-win-big-reprap-festival>

2023 CU Boulder | New seed grants from the Engineering Education and AI-Augmented Learning research theme will support range of topics

<https://www.colorado.edu/irt/engineering-education-ai/2023/05/19/new-seed-grants-engineering-education-and-ai-augmented-learning-research-theme-will>

2021 CU Boulder | Sandra Bae receives ARCS and KASF scholarship

<https://www.colorado.edu/atlas/2021/09/08/sandra-bae-receives-arcs-and-kasf-scholarships>

2017 CONNECT EXPO | SOFA CHICAGO 2017 Exhibition

Printing Press: Chubb (pg. 10-11).

2017 AIGA and IDSA | Better Together Design Exhibition

Printing Press: AIGA (pg. 8-9).

2017 UC Davis | 'OneClimate' a Call to Arms

<https://www.ucdavis.edu/news/oneclimate-call-arms>