BRIAN K. PLANCHER

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ACADEMIC POSITIONS

BARNARD COLLEGE, COLUMBIA UNIVERSITY: New York, NY
- Assistant Professor of Computer Science   JULY 2022 – PRESENT

FU FOUNDATION SCHOOL OF ENGINEERING AND APPLED SCIENCE, COLUMBIA UNIVERSITY: New York, NY
- Affiliate Faculty in Computer Science   JUNE 2023 – PRESENT
- Affiliate Faculty in Electrical Engineering   JUNE 2024 – PRESENT

EDUCATION

HARVARD UNIVERSITY: Cambridge, MA
- PhD Engineering Sciences: Electrical Engineering with a focus in Robotics; GPA: 3.9/4.0   MAY 2022
  - Dissertation: "GPU Acceleration for Real-time, Whole-Body, Nonlinear Model Predictive Control"
  - Advisors: Vijay Janapa Reddi and Scott Kuindersma.
- MEng in Engineering Sciences: Electrical Engineering with a focus in Robotics; GPA: 3.9/4.0   MAY 2018
  - Thesis: "Parallel and Constrained Differential Dynamic Programming for Model Predictive Control"
  - Advisor: Scott Kuindersma

MASSACHUSSETS INSTITUTE OF TECHNOLOGY (MIT): Cambridge, MA
- Advanced Study Non-Degree Student; GPA: 5.0/5.0   JUNE 2016

HARVARD UNIVERSITY: Cambridge, MA
- B.A. Magna Cum Laude in Computer Science with a Minor in Economics; GPA: 3.9/4.0   MAY 2013
  - Thesis: "Hacking the White House: Election Fraud in the Digital Age"
  - Advisor: Greg Morrisett

AWARDS AND RECOGNITON

- Best Poster Award at the TC on Model Based Optimization for Robotics Virtual Poster Session   JULY 2024
- Best Paper in Automation at ICRA 2024   MAY 2024
- Finalist for Best Conference Paper at ICRA 2024   APRIL 2024
- Finalist for Best Student Paper at ICRA 2024   APRIL 2024
- Best Poster Award at the IROS Workshop: Methods for Objective Comparison of Results in Intelligent Robotics Research   OCT 2023
- Blue Ribbon TC Award given to the RAS TC on Model-Based Optimization for Robotics while Co-Chair   SEPT 2023
- IEEE Micro Top Picks – Honorable Mention   JAN 2022
- Harvard Faculty of Arts and Sciences Certificate in Undergraduate Mentoring   APRIL 2021
- The Derek Bok Center Distinction in Teaching Award   FALL 2017,18,19,20
- The Derek Bok Center Teaching Certificate   DEC 2019
- Best Poster Award at the ICRA Workshop: Toward Online Optimal Control of Dynamic Robots   MAY 2019
- National Science Foundation Graduate Research Fellowship (NSF GRFP)   APRIL 2018

GRANTS

All award amounts represent my share of the grant if not otherwise specified.

ACTIVE AWARDS

- Sole PI for the National Science Foundation (NSF) 22-632 Cyberinfrastructure for Sustained   2024 – 27
  Scientific Innovation (CSSI) award:
  "Elements: RUI: Accessible GPU-Accelerated Edge Optimal Control Library and Benchmarks"
  Award #2411369: $590,548
- Sole PI for the National Science Foundation (NSF) 23-576 Computer and Information Science and Engineering   2023 – 25
  Research Initiation Initiative (CRII) award:
  "CRII: OAC: RUI: Real-Time, Mixed-Integer Model Predictive Control via Learned GPU-Acceleration"
  Award #2246022: $174,957
  - Additionally Awarded a Research Experiences for Undergraduates (REU) Supplement – $24,000
  - Additionally Awarded a Career-Life Balance (CLB) Supplement – $24,898
- Co-PI for the IEEE Robotics and Automation Society Technical Education Programs (RAS-TEP) award: 2024 – 25
  "Optimization for Robotics Summer School"
  Award: $25,000 to support the costs of the school and to offer scholarships to participants from underrepresented groups

PRIOR AWARDS

- Co-PI for the <u>IEEE Computer Society</u> Diversity and Inclusion Fund award: 2022
  "TinyML Outreach Workshop with the Navajo Nation"
  Award: $5,000 for stipends and hardware for workshop participants

PUBLICATIONS

<u>Google Scholar</u>: h-index=14; i10-index=18

Conferences are the primary publication venue in robotics and senior authors are typically listed last

PREPRINTS (UNDER REVIEW)

(P1) M. Wolfley, C. Ho, **B. Plancher**, "Improving the Representation of Undergraduate Women in Robotics: A Literature Review," October 2024.

(P2) C. J. Carver, H. Schwartz, T. Itagaki, Z. Englhardt, K. Liu, M. Manik, C. Chang, V. Iyer, **B. Plancher**, X. Zhou, "Set Phasers to Stun: Beaming Power and Control to Mobile Microrobots with Laser Light," August 2024.

(P3) S. Schoedel, K. Nguyen, E. Nedumaran, **B. Plancher**, Z. Manchester, "Code Generation for Conic Model-Predictive Control on Microcontrollers with TinyMPC," arXiv, March 2024.

(P4) R. Ghosal, E. Sacher, P. Samaratunga, S. M. Neuman, **B. Plancher**, V. Janapa Reddi, "Studying the Samplers: Workload and Performance Analysis of the Computational Bottlenecks in Sampling-Based Motion Planning," March 2024.

(P5) M. Stewart, E. Moss, P. Warden, **B. Plancher**, S. Kennedy, M. Sloane, V. Janapa Reddi, "Materiality and Risk in the Age of Pervasive AI Sensors," arXiv, February 2024.

(P6) M. Stewart, P. Warden, Y. Omri, S. Prakash, J. Santos, S. Hymel, B. Brown, J. MacArthur, N. Jeffries, **B. Plancher**, V. Janapa Reddi, "Datasheets for Machine Learning Sensors," arXiv, June 2023.

JOURNAL ARTICLES

(J1) B. Boroujerdian, H. Genc, S. Krishnan, P. Bardienus, B. Duisterhof, **B. Plancher**, K. Mansoorshahi, M. Almeida, A. Faust, V. Janapa Reddi. "The Role of Compute in Autonomous Aerial Vehicles." in IEEE Transactions on Computers, July 2022.

(J2) V. Janapa Reddi, **B. Plancher**, S. Kennedy, L. Moroney, P. Warden, A. Agarwal, C. Banbury, M. Banzi, M. Bennett, B. Brown, S. Chitlangia, R. Ghosal, S. Grafman, R. Jaeger, S. Krishnan, M. Lam, D. Leiker, C. Mann, M. Mazumder, D. Pajak, D. Ramaprasad, J. E. Smith, M. Stewart, D. Tingley, "Widening Access to Applied Machine Learning with TinyML," in Harvard Data Science Review, January 2022.

(J3) **B. Plancher**, S. M. Neuman, T. Bourgeat, S. Kuindersma, S. Devadas, V. Janapa Reddi, "Accelerating Robot Dynamics Gradients on a CPU, GPU, and FPGA," in IEEE Robotics and Automation Letters (RA-L), January 2021.
  - Additionally dual-accepted under the RAL+ICRA option for presentation at the IEEE International Conference on Robotics and Automation (ICRA), Xi'an China and Virtual, June 2021.

REFFEREED CONFERENCE PROCEEDINGS

(C1) E. Selman-Housein, **B. Plancher**, "Improving the Representation of Undergraduate Women in Cybersecurity: A Literature Review," ACM Technical Symposium on Computer Science Education (SIGCSE-TS), Pittsburg, PA, USA, February 2025.

(C2) S. M. Neuman, **B. Plancher**, V. Janapa Reddi, "Invited: The Magnificent Seven Challenges and Opportunities in Domain-Specific Accelerator Design for Autonomous Systems," ACM/IEEE Design Automation Conference (DAC), San Francisco, CA, USA, June 2024.

(C3) K. Nguyen, S. Schoedel, A. Alavilli, **B. Plancher**, Z. Manchester, "TinyMPC: Model-Predictive Control on Resource-Constrained Microcontrollers," in the IEEE International Conference on Robotics and Automation (ICRA), Yokohama, Japan, May 2024.
  - Best Paper in Automation at IEEE ICRA 2024
  - Finalist for Best Conference Paper at IEEE ICRA 2024
  - Finalist for Best Student Paper at IEEE ICRA 2024

(C4) E. Adabag, M. Atal, W. Gerard, **B. Plancher**, "MPCGPU: Real-Time Nonlinear Model Predictive Control through Preconditioned Conjugate Gradient on the GPU," in the IEEE International Conference on Robotics and Automation (ICRA), Yokohama, Japan, May 2024.
  - Best Poster Award at the 2024 IEEE TC on Model Based Optimization for Robotics Virtual Poster Session

(C5) X. Bu and **B. Plancher**, "Symmetric Stair Preconditioning of Linear Systems for Parallel Trajectory Optimization," in the IEEE International Conference on Robotics and Automation (ICRA), Yokohama, Japan, May 2024.

(C6) L. Grossman and **B. Plancher**, "Differentially Encoded Observation Spaces for Perceptive Reinforcement Learning," in the IEEE International Conference on Robotics and Automation (ICRA), Yokohama, Japan, May 2024.

(C7) V. Mayoral-Vilches, J. Jabbour, Y. Hsiao, Z. Wan, A. Martínez-Fariña, M. Crespo-Alvarez, M. Stewart, J. Reina-Muñoz, P. Nagras, G. Vikhe, M. Bakhshalipour, M. Pinzger, S. Rass, S. Panigrahi, G. Corradi, N. Roy, P. B. Gibbons, S. M. Neuman, **B. Plancher**, V. Janapa Reddi, "RobotPerf: An Open-Source, Vendor-Agnostic, Benchmarking Suite for Evaluating Robotics Computing System Performance," in the IEEE International Conference on Robotics and Automation (ICRA), Yokohama, Japan, May 2024.
  - Best Poster Award for preliminary results at the Workshop on Methods for Objective Comparison of Results in Intelligent Robotics Research at the 2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (iROS)

(C8) **B. Plancher**, M. Zennaro, M. Rovai, V. Janapa Reddi, S. Buttrich, J. Ellis, N. Goveas, L. Kazimierski, J. Lopez Sotelo, M. Lukic, D. Mendez, R. Nordin, A. Oliva Trevisan, M. Pavan, M. Roveri, M. Rub, J. Tum, M. Verhelst, S. Abdeljabar, S. Adebayo, T. Amberg, H. Aworinde, J. Bagur, G. Barrett, N. Benamar, B. Chaudhari, R. Criollo, D. Cuartielles, J. A. Ferreira Filho, S. Gizaw, E. Gousev, A. Grande, S. Hymel, P. Ing, P. Manandhar, P. Manzoni, B. Murmann, E. Pan, R. Paskauskas, E. Pietrosemoli, T. Pimenta, "TinyML4D: Scaling Embedded Machine Learning Education in the Developing World," AAAI 2024 Spring Symposium on Increasing Diversity in AI Education and Research, San Francisco, CA, USA, March 2024.
- ▪ Invited to be Presented as an Extended Session at the Symposium [Link].

(C9) S. M. Neuman, R. Ghosal, T. Bourgeat, **B. Plancher**, V. Janapa Reddi, "RoboShape: Using Topology Patterns to Scalably and Flexibly Deploy Accelerators Across Robots," in the International Symposium on Computer Architecture (ISCA), Orlando, FL, USA, June 2023.

(C10) L. Grossman and **B. Plancher**, "Just Round: Quantized Observation Spaces Enable Memory Efficient Learning of Dynamic Locomotion," in the IEEE International Conference on Robotics and Automation (ICRA), London, UK, May 2023.

(C11) J. Blanchard, J. R. Hott, V. Berry, R. Carroll, B. Edmison, R. Glassey, O. Karnalim, **B. Plancher**, S. Russell, "Stop Reinventing the Wheel! Promoting Community Software in Computing Education," in the 2022 Working Group Reports on Innovation and Technology in Computer Science Education (ITiCSE-WGR), Dublin, Ireland, December 2022.

(C12) V. Mayoral-Vilches, S. M. Neuman, **B. Plancher**, V. Janapa Reddi, "RobotCore: An Open Architecture for Hardware Acceleration in ROS 2," in the in IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Kyoto, Japan, October 2022.

(C13) S. M. Neuman, **B. Plancher**, B. P. Duisterhof, S. Krishnan, C. Banbury, M. Mazumder, S. Prakash, J. Jabbour, A. Faust, C.H.E. de Croon, V. Janapa Reddi, "Tiny Robot Learning: Challenges and Directions for Machine Learning in Resource-Constrained Robots," in the IEEE International Conference on Artificial Intelligence Circuits and Systems (AICAS), Incheon, Korea, June 2022.

(C14) **B. Plancher,** S. M. Neuman, R. Ghosal, S. Kuindersma, V. Janapa Reddi, "GRiD: GPU-Accelerated Rigid Body Dynamics with Analytical Gradients," IEEE International Conference on Robotics and Automation (ICRA), Philadelphia PA, May 2022.

(C15) B. Boroujerdian, R. Ghosal, J. Cruz, **B. Plancher**, V. Janapa Reddi, "RoboRun: A Robot Runtime to Exploit Spatial Heterogeneity," in the Design Automation Conference (DAC), Virtual, December 2021.

(C16) S. M. Neuman, **B. Plancher**, T. Bourgeat, T. Tambe, S. Devadas, V. Janapa Reddi, "Robomorphic Computing: A Design Methodology for Domain-Specific Accelerators Parameterized by Robot Morphology," in the ACM International Conference on Architecture Support for Programming Languages and Operating Systems (ASPLOS), Virtual, April 2021.
- ▪ IEEE Micro Top Picks 2022 – Honorable Mention

(C17) **B. Plancher**, C. Brumaar, I. Brumar, L. Pentecost, S. Rama, D. Brooks, "Application of Approximate Matrix Multiplication to Neural Networks and Distributed SLAM," in the IEEE High Performance Extreme Computing Conference (HPEC), Waltham, MA, September 2019.

(C18) **B. Plancher** and S. Kuindersma, "A Performance Analysis of Parallel Differential Dynamic Programming on a GPU," in the Workshop on the Algorithmic Foundations in Robotics (WAFR), Merida, Mexico, December 2018.

(C19) **B. Plancher**, Z. Manchester, S. Kuindersma, "Constrained Unscented Dynamic Programming," in the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Vancouver, Canada, September 2017.

(C20) S. Karaman, A. Anders, M. Boulet, J. Connor, K. Gregson, W. Guerra, O. Guldner, M. Mohamoud, **B. Plancher**, R. Shin, J. Vivilecchia, "Project-based, collaborative, algorithmic robotics for high school students: Programming self-driving race cars at MIT," in the IEEE Integrated STEM Education Conference (ISEC), Princeton, NJ, March, 2017.

REFFEREED MAGAZINE ARTICLES AND COLUMNS

(M1) E. Fields, C. Ho, M. J. Kim, Z. Wu, **B. Plancher**, "Underrepresentation of Women in Robotics Research [Women in Engineering]," IEEE Robotics and Automation Magazine (RAM), March 2024.

(M2) S. Prakash, M. Stewart, C. Banbury, M. Mazumder, P. Warden, **B. Plancher**, V. Janapa Reddi, "Is TinyML Sustainable? Assessing the Environmental Impacts of Machine Learning on Microcontrollers," Communications of the ACM (CACM), November 2023.

(M3) P. Warden, M. Stewart, **B. Plancher**, S. Katti, V. Janapa Reddi, "Machine Learning Sensors: A Design Paradigm for the Future of Intelligent Sensors," Communications of the ACM (CACM), November 2023.

REFEREED WORKSHOP PUBLICATIONS AND POSTERS

(W1) E. Adabag, X. Bu, K. Nguyen, S. Schoedel, A. Alavilli, M. Atal, W. Gerard, E. Nedurmaran, Z. Manchester, **B. Plancher**. "Optimizing at All Scales: Edge (Non)linear Model Predictive Control from MCUs to GPUs," Frontiers of Optimization for Robotics Workshop at the Robotics Science and Systems Conference (RSS), Delft, Netherlands, July 2024.
- ▪ Additionally Invited for a Spotlight Talk at the Workshop

(W2) **B. Plancher**, "Parallel Optimization for Robotics: An Undergraduate Introduction to GPU Parallel Programming and Numerical Optimization Research," IEEE International Parallel and Distributed Processing Symposium Workshops (IPDPSW), San Francisco, CA, USA, May 2024.

(W3)   W. Xie, **B. Plancher**, "Can Large Language Models Reduce the Barriers to Entry for High School Robotics?" Robots for Learning Workshop at the IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN), Busan, South Korea and Remote, August 2023.

(W4)   **B. Plancher**, "Tiny Robot Learning: Expanding Access to Edge ML as a Step Toward Accessible Robotics," Lowering Barriers for Robotics Research Workshop at the Robotics Science and Systems (RSS) Conference, Daegu, South Korea and Remote, July 2023.

(W5)   M. Zennaro, **B. Plancher**, V. Janapa Reddi, "Bridging the Digital Divide: The Promising Impact of TinyML for Developing Countries," at the UN 8th Multi-stakeholder Forum on Science, Technology and Innovation for the Sustainable Development Goals, New York, NY, USA and Remote, May 2023.

(W6)   S. Kennedy and **B. Plancher**, "Voice Interfaces, Gender, and Race: An Intersectional Analysis," in the Gendering Robots (GenR) Workshop at the IEEE International Conference on Robot and Human Interactive Communication (RO-MAN), Naples, Italy, August 2022.

(W7)   J. Blanchard, J. R. Hott, V. Berry, R. Carroll, B. Edmison, R. Glassey, O. Karnalim, **B. Plancher**, S. Russell, "Leveraging Community Software in CS Education to Avoid Reinventing the Wheel," in the ACM Conference on Innovation and Technology in Computer Science Education (ITiCSE), Dublin, Ireland, July 2022.

(W8)   J. Jabbour, S. M. Neuman, M. Mazumder, C. Banbury, S. Prakash, **B. Plancher**, and V. Janapa Reddi, "Closing the Sim-to-Real Gap for Ultra-Low-Cost, Resource-Constrained, Quadruped Robot Platforms," in the Closing the Sim2Real Gap workshop at the Robotics Science and Systems (RSS) Conference, New York, New York, June 2022.

(W9)   M. Zennaro, **B. Plancher,** and V. Janapa Reddi, "TinyML: Applied AI for Development," at the UN 7th Multi-stakeholder Forum on Science, Technology and Innovation for the Sustainable Development Goals. New York, NY, USA and Remote. May 2022.

(W10) **B. Plancher** and V. Janapa Reddi, "The Tiny Machine Learning Open Education Initiative (TinyMLedu)," ACM Technical Symposium on Computer Science Education (SIGCSE), Providence, Rhode Island, March 2022.

(W11) **B. Plancher** and S. Kuindersma, "Realtime Model Predictive Control using Parallel DDP on a GPU," in the workshop Toward Online Optimal Control of Dynamic Robots at the International Conference on Robotics and Automation (ICRA), Montreal, Canada, May 2019.
   ▪ Winner of the Best Poster Award at the Workshop

OTHER PUBLICATIONS AND POSTERS

(O1)   J. Jabbour, J. Wang, **B. Plancher**, "Receding Diffusion: Domain Informed, Efficient Diffusion Path Planning for Dynamic Environments," Northeast Robotics Colloquium (NERC), Amherst, Massachusetts, September 2024.

(O2)   A. E. Yilmaz, T. Bourgeat, **B. Plancher**, S. M. Neuman, "Accelerating Rigid Body Dynamics through Variable Fixed-Precision with Provable Error-Bounds," Northeast Robotics Colloquium (NERC), Amherst, Massachusetts, September 2024.

(O3)   K. Awotwi, Z. Pestrikov, A. Sharma, D. Tuchman, **B. Plancher**, "Towards a Comprehensive GPU-Accelerated Rigid Body Dynamics Library: Extending GRiD," Northeast Robotics Colloquium (NERC), Amherst, Massachusetts, September 2024.

(O4)   A. Du, **B. Plancher**, "Towards Real-Time Batched Trajectory Optimization with MPCGPU," Northeast Robotics Colloquium (NERC), Amherst, Massachusetts, September 2024.

(O5)   M. Zennaro, **B. Plancher**, M. Stewart, V. Janapa Reddi, "AI in the developing world: how 'tiny machine learning' can have a big impact," The Conversation, February 2024.

(O6)   E. Adabag, M. Atal, W. Gerard, **B. Plancher**, "Accelerating Nonlinear MPC with Warm Started Iterative Solvers on GPUs," the IEEE-RAS Technical Committee on Model-Based Optimization for Robotics Virtual Poster Session, Remote, July 2023.

(O7)   C. Ho and **B. Plancher,** "Gender Diversity in Robotics Research," Northeast Robotics Colloquium (NERC), Lowell, Massachusetts, October 2022.

(O8)   P. Warden, M. Stewart, **B. Plancher**, C. Banbury, S. Prakash, E. Chen, Z. Asgar, S. Katti, and V. Janapa Reddi, "Machine Learning Sensors," arXiv preprint, June 2022.

TEACHING

BARNARD COLLEGE, COLUMBIA UNIVERSITY: New York, NY – *Instructor of Record*   FALL 2022 – PRESENT
- **COMS BC 3159: Parallel Optimization for Robotics** (Spring 2023, 24, Fall 24)
   ▪ Designed a new 50 student course (increased from 30 students in Spring 23) at the intersection of robotics and both numerical optimization and computer architecture / systems exploring the use of parallel programming on CPUs and GPUs to accelerate numerical optimization algorithms through the lens of robot motion planning and control
   ▪ Designed and gave lectures on computer system design, parallel programming on the CPU and GPU using (CUDA) C++, (nonlinear) (trajectory) optimization, and numerical optimal control
   ▪ Developed written assignments and coding assignments in both python and (CUDA) C++ covering the core course topics as well as a hands-on, team-based, final project to enable students to integrate and apply their learnings from the semester and practice presenting and technical writing. Student project highlights include:
      ▪ "Preconditioned Conjugate Gradient on the GPU" in Spring 2023 which led to an ICRA 2024 Publication (C4)
   ▪ Published a Refereed Workshop paper on the design and pilot of the course at EduPar-24 (W2)

- **COMS BC 3449: Applied Computing – Research and Industry Perspectives** (Spring 2023, 24, Fall 24)
  - Designed a new 16 student course (reduced from 30 to increase attention to each student's unique project) providing a unifying structure to support hands-on, computational student projects ranging from academic research to industry collaborations to independent passion projects (course ran as COMS BC 3997: New Directions in Computing rotating topics course in Spring 23, 24 and called Projects in Computer Science in Spring 23). Student project highlights include:
    - A multiple pivot LLM project in Spring 2024 which led to a $250k pre-seed investment
  - Designed lectures on: performance engineering, cyber security, web development, and technical writing and presentation
  - Recruited guest speakers from academia and industry to present on topics including: responsible AI, startup engineering, accessible user interface design, working with legacy software systems, and the business of technology
  - Mentored student projects with one-on-one writing and presenting support, high level direction, and technical debugging
- **COMS BC 3997 - F22: New Directions in Computing: Introduction to Robotics Engineering** (Fall 2022)
  - Designed a new 20 student course providing a hands-on introduction to computational robotics for computer scientists
  - Designed and gave lectures covering algorithms for perception, mapping and localization, planning, control, and learning
  - Developed written assignments and coding assignments in python as well as a hands-on final project using physical robot hardware to connect the algorithms learned in class into the physical world and reinforce their tradeoffs

edX Inc: Cambridge, MA – *Teaching Staff Lead*   SUMMER 2020 – SUMMER 2022
- **HarvardX Professional Certificate in Tiny Machine Learning (TinyML) MOOC** [Course 1-3 Link Course 4]
  - Co-designed a free, hands-on, project-based professional certificate taught through three 6-week courses (and an optional fourth course) on the EdX platform covering the emerging field of Tiny Machine Learning (deploying machine learning onto microcontrollers for machine learning at the edge) with the aim of democratizing access to this developing field
  - Over 100,000 students from over 190 countries enrolled as of July 2024 since the four courses launched in September 2020, December 2020, February 2021, and March 2022 respectively
  - Served as the laboratory instructor both co-designing hands-on exercises as well as recording video walkthroughs
  - Managed the 10-person course staff to ensure that content was created, reviewed, and produced in a timely manner
  - Led and managed external relations for the course team coordinating with edX, Google, and Arduino
  - Co-designed course materials including video lectures, readings, code walkthroughs, assessments, and discussion forums
  - Released all course materials open-source to enable global adaptation for further access to TinyML education [link]

HARVARD UNIVERSITY: Cambridge, MA – *Head Teaching Fellow (Head TA)*   FALL 2017-20
- **CS 249r - Special Topics in Edge Computing - Autonomous Machines** (Fall 2019) and **Tiny Machine Learning** (Fall 2020)
  - Co-designed 40-50 student courses at the intersection of artificial intelligence (robotics and machine learning) and computer architecture / embedded systems
  - Designed and gave lectures for the introduction to robotics and introduction to machine learning sections of the courses
  - Co-developed hands-on project-based assignments (e.g., training TinyML models with Google Colab and deploying on Arduinos) and course infrastructure/tools (e.g., online paper discussion forum)
  - Mentored student teams pursuing research-based final projects
- **CS 182: Introduction to Artificial Intelligence** (Fall 2017-2018)
  - Managed a team of 11 teaching fellows supporting the 150 student course to ensure sections and office hours were held, exams and homework assignments were graded, and student questions on the online forum were answered.
  - Designed and gave lectures: "Introduction to Robotics and Path Planning I/II" and the related assignment/exam questions
  - Co-Designed and gave a new set of weekly recitations that mapped the weekly course content to cross-cutting themes
  - Co-developed course coding and written (theoretical) assignments, and course infrastructure/tools (e.g., autograders)
  - Mentored student teams pursuing research-based final projects

MIT / HARVARD UNIVERSITY: Cambridge, MA – *Teaching Assistant*   FALL 2017,18,19,21
- Harvard's 15 student section of MIT's **MAS.863: How to Make Almost Anything**
  - Held office hours, led introductory sessions for course tools, aided students in lab work, machine usage, and project design
  - Gave recitations: "Introduction to Embedded Programming", "Introduction to Electronics Fabrication and Design"

MIT LINCOLN LABORATORIES BEAVER WORKS: Cambridge, MA – *Associate Instructor*   SUMMER 2016,17,18,19
- **RACECAR Mini Grand Prix Challenge**: a hands-on, intensive, residential, project-based, free to attend, 4-week program for high school students interested in studying STEM
  - Worked with 9-12 teams of 4-6 students to teach programming concepts and robotic algorithm design through the completion of fast autonomous navigation tasks using 1/10 scale racecars using Python/ROS
  - Co-designed weekly challenges to ensure all teams developed the technical skills needed for the final race
  - Co-designed and co-built the final race track spanning an entire ice hockey rink

ADVISING

PHD ADVISOR
- Jonathan S. Kent (Columbia University):   SEPT 2024 – PRESENT
  Autonomous UxV Swarm Control and Communication

MASTERS THESIS ADVISOR
- Ishaan Manajan (Columbia University):   SEPT 2024 – PRESENT
  Provably Safe Reinforcement Learning

UNDERGRADUATE THESIS ADVISOR
- Dhilan Ramaprasad (Harvard University): Highest Honors   MAY 2022
  Teaching Embedded Systems Programming
- Lev Jacob Grossman (Harvard University): Highest Honors   MAY 2020
  Reinforcement Learning to Enable Robust Robotic Model Predictive Control
- John Alex Keszler (Harvard University): Honors   MAY 2019
  FPGA Acceleration of Motion Planning Algorithms for Robotics Applications

PRE-DOCTORAL RESEARCHER ADVISOR
- Kwamena Awotwi: MAY 2024 – PRESENT
  GPU Acceleration of Rigid Body Dynamics
- Jiayi Wang: MAY 2024 – PRESENT
  Receding Diffusion for Real-Time Robot Motion Planning
- Abhinav Sharma: SEPT 2023 – PRESENT
  GPU Acceleration of Rigid Body Dynamics
- En Kai "Gino" Zhang, Elvina Wibisono: SEPT 2024 – DEC 2024
  Tiny Drone Racing
- Yana Botvinik: MAY 2024 – DEC 2024
  GPU Acceleration of Linear System Solvers

MASTERS THESIS COMMITTEE
- Basel Nitham Hindi (Columbia University)   DEC 2023
  Computer Vision-Powered Applications for Interpreting and Interacting with Movement

RESEARCH MENTOR
- National Science Foundation Research Experiences for Undergraduates (NSF REU)
  - Alexander Du, Alice Lin: *GPU Acceleration of Optimal Control Solvers*   SUMMER 2024
- Columbia College Summer Funding Program and Columbia Engineering Summer Internship Program
  - Danelle Tuchman: *GPU Acceleration of Rigid Body Dynamics*   SUMMER 2024
  - Alice Diakova: *Learning Sensors for Low-Cost Robots*   SUMMER 2023
  - Ena Selman-Housein: *Accessibility, Retention, & Diversity in Introductory CS and Cybersecurity*
- Columbia University Summer Undergraduate Research Experience (SURE) Program
  - Vidushi Jindal: *Perception, Mapping, and Localization on Embedded Systems*   SUMMER 2024
  - Kevin Han: *Federated Learning at the Edge for UAV Swarms*
- Egleston Scholars Summer Internship Program
  - Jonathan Nalikka: *Constrained Parallel Differential Dynamic Programming*   SUMMER 2023
- Barnard College Summer Research Institute (SRI)
  - Aliya Tang: *Perception, Mapping, and Localization on Embedded Systems*   SUMMER 2024
  - Nicole Ineza, Khadija Siddiqui, Annie Wang, Catherine Zhao: *Constrained Parallel Differential Dynamic Programming*
  - Yana Botvinnik, Xian Jiang: *GPU Acceleration of Linear System Solvers*   SUMMER 2023
  - Claudia Lihar, Anagha Ram: *Constrained Parallel Differential Dynamic Programming*
  - Allyce Chung, Merrick Wolfley, Julianna Yu: *Accessibility, Retention, & Diversity in Introductory CS and Cybersecurity*
  - Emily Burnett, Neasha Mittal, Chau Nguyen, Kimiya Shahamat: *GPU Acceleration of Robot Dynamics Algorithms*
  - Aliya Tang, Elvina Wibisono: *Perception, Mapping, and Localization on Embedded Systems*
  - Britney Aparicio, Tramy Dong: *Learning Sensors for Low-Cost Robots*
  - Susannah Abrams: *GPU Acceleration of Robot Dynamics Algorithms*   SUMMER 2022
  - Tara Bogavelli: *Sim-to-Real Reinforcement Learning for Low-Cost Walking Robots*
  - Chloe Ho: *Gender Diversity in Robotics Research*
- Other Mentored Independent and Group Research Projects
  - Charles Chen, Nick Thevinin: *Tiny Drone Racing*   FALL 2024
  - Alexander Du, Nadim Kanazi Seyoung Ree, Louis Zheng: *GPU Acceleration of Optimal Control Solvers*
  - Danelle Tuchman, Zachary Pestrikov: *GPU Acceleration of Rigid Body Dynamics*
  - Nicole Ineza, Catherine Zhao, Nagavasavi Jeepalyam: *Constrained Parallel Differential Dynamic Programming*
  - Anupam Bhakta, Kevin Qiu: *Approximation and Acceleration of Optimal Control*
  - Chih Huang, Cael Yasutake: *Benchmarking and Acceleration of Sample-Based Motion Planning*
  - Aidan Eichman: *Advanced Sports Analytics*
  - Eric Feng: *Constrained Parallel Differential Dynamic Programming*   SUMMER 2024
  - Nadim Kanazi: *GPU Acceleration of Optimal Control Solvers*
  - Zachary Pestrikov: *GPU Acceleration of Rigid Body Dynamics*

- Merrick Wolfley*: Women in Robotics and Cyber Undergraduate Education*
- Seyoung Ree, Justin Haddad: *GPU Acceleration of Optimal Control Solvers*   SPRING 2024
- Eric Feng, William Gerard, Nagavasavi Jeepalyam: *Constrained Parallel Differential Dynamic Programming*
- Anupam Bhakta, Justin Jiang, Kevin Qiu, Shuo Sha: A*pproximation and Acceleration of Optimal Control*
- Kwamena Awotwi, Naren Loganathan, Carly Kiang, Danelle Tuchman: *GPU Acceleration of Rigid Body Dynamics*
- Britney Aparicio, Barkha Seth, Nicholas Thevenin, Luci Feinberg, Aliya Tang, Elvina Wibisono: *Sensing, Perception, and Mapping for Low-Cost Robots*
- Shobini Iyer, Jiayi Wang: *Robot Learning*
- Chloe Ho, Merrick Wolfley*: Accessibility, Retention, & Diversity in Robotics and Computing*
- Khushi Tyagi*: Fall Detection for the Elderly with Embedded Systems*
- William Gerard: *Constrained Parallel Differential Dynamic Programming*   FALL 2023
- Britney Aparicio, Alice Diakova, Tramy Dong, Barkha Seth, Luci Feinberg, Aliya Tang, Elvina Wibisono: *Sensing, Perception, and Mapping for Low-Cost Robots*
- Carly Kiang, Chloe Nguyen, Kimiya Shahamat, Danelle Tuchman: *GPU Acceleration of Rigid Body Dynamics*
- Ena Selman-Housein: *Accessibility, Retention, & Diversity in Introductory CS and Cybersecurity*
- Leyi Cui: *Injury Prevention in Dance through an Automated Coach*
- Emre Adabag, William Gerard: *GPU Acceleration of Optimal Control Solvers*   SUMMER 2023
- Jessica Zhang: *Proving the Optimality of the Symmetric Stair Preconditioner*   SPRING 2023
- Antonio Aranda, William Gerard, Avigayil Helman, Nick Luo, Annie Song: *Constrained Parallel Differential Dynamic Programming*
- Emre Adabag, Miloni Atal, Yana Botvinnik, Srishti Srivastava, Seojin "Heidi" Yoon: *GPU Acceleration of Numerical Optimization and Optimal Control*
- Catherine Ji, Chloe Nguyen, Kimiya Shahamat, Danelle Tuchman: *GPU Acceleration of Rigid Body Dynamics*
- Luci Feinberg, Elvina Wibisono, Eris Gao, Kevin Luo, Habeeba Mansour, Nolan Tremelling: *Sensing, Perception, and Mapping for Low-Cost Robots*
- Donghan Kim: *Fast Optimization Methods for SLAM Algorithms*
- Rachel Peng: *Profiling the Energy Consumption of Datacenter GPUs*
- Kofi Meighan: *Developing a Low-Cost Self-Driving Car Platform for STEM Education*
- Alekhya Maram: *Design for Digital Wellbeing*
- Emre Adabag, Miloni Atal: *GPU Accelerated of Numerical Optimization and Optimal Control*   FALL 2022
- Antonio Aranda, William Gerard: *Constrained Parallel Differential Dynamic Programming*
- Catherine Ji, Kimiya Shahamat: *GPU Acceleration of Rigid Body Dynamics*
- Harvard College Women in STEM Mentorship Program   FALL 2021 – SPRING 2022
- Try AI: "A program designed to introduce early undergraduate students, particularly those identifying   FALL 2020
as women, Black, Latinx, and/or Indigenous, to research in Artificial Intelligence"

INVITED TALKS, SEMINARS, AND PANELS

- "Structure Exploitation and Preconditioning for Real-Time GPU-Accelerated Optimization at the Edge"   MAR 2025
  SIAM Conference on Computational Science and Engineering, Fort Worth, TX, USA
- "Challenges and Opportunities for Computational Robotics Across Scales"   NOV 2024
  Intel Neuromorphic Computing Labs Seminar Series, Remote
- "Acceleration of (Nonlinear) Optimization for Robotics through Co-Design: from MCUs to GPUs"   OCT 2024
  INFORMS Annual Meeting, Seattle, WA, USA
- "Optimization for Robotics through Co-Design"   OCT 2024
  New York University, Robotics Seminar Series, NY, USA
- "Towards a Comprehensive Package for GPU-Accelerated Trajectory Optimization and Rigid Body Dynamics"   SEPT 2024
  Northeast Robotics Colloquium (NERC), Amherst, Massachusetts, USA
- "Optimization for Robotics through Co-Design"   SEPT 2024
  Barnard Computation Science Center: Computing Across Disciplines Talk Series, New York, NY, USA
- "From Convolutional Filters to Computer Vision at the Extreme Edge"   JULY 2024
  "Tiny Robots: Edge Computational Challenges and Opportunities"
  "Sustainable & Responsible TinyML"
  Workshop on TinyML for Sustainable Development, Sao Paulo, Brazil
- "Optimizing at All Scales: Edge (Non)linear Model Predictive Control from MCUs to GPUs"   JULY 2024
  Lightning Talk at the Frontiers of Optimization for Robotics Workshop at the Robotics Science and Systems Conference (RSS), Delft, Netherlands
- "Panelist: Sustainable Robotics and Climate Change"   MAY 2024
  Workshop on Robots and Roboticists in the Age of Climate Change at the IEEE International Conference on Robotics and Autonomation (ICRA), Yokohama, Japan
- "Responsible TinyML"   MAY 2024
  SciTinyML-24: Workshop on Machine Learning on Low-Power Devices: Applications and Advanced Topics, Remote

- "TinyML4D: Scaling Embedded Machine Learning Education in the Developing World - A Hands-On Workshop" MAY 2024
  AAAI Spring Symposium on Increasing Diversity in AI Education and Research, San Francisco, CA, USA
- "The Big Impact of TinyML: Embedded Machine Learning at the Extreme Edge" JULY 2023
  1st Morocco AI Summer School, Ifrane, Morocco and Remote
- "ML Sensors and the Environmental Impact of TinyML" JULY 2023
  "Launching TinyML edX and Long Term Support"
  EdgeMLUP-23: Workshop on Widening Access to TinyML Network by Establishing Best Practices in Education, Trieste, Italy
- "Is TinyML Sustainable? Assessing the Environmental Impacts of Machine Learning on Microcontrollers" APR 2023
  SciTinyML-23: Workshop on Scientific Use of Machine Learning on Low-Power Devices: Applications and Advanced Topics, Remote
- "GPU Acceleration for Real-Time, Whole-Body, Nonlinear Model Predictive Control" APR 2023
  Columbia University Computer Science Faculty Seminar, New York, NY, USA
- "GPU Acceleration for Real-Time, Whole-Body, Nonlinear Model Predictive Control" NOV 2022
  University of Waterloo MME Departmental Seminar Series, Remote
- "Machine Learning for HPC" OCT 2022
  Energy Efficient High Performance Computing Working Group, Remote
- "Keyword Spotting with Convolutional Neural Networks" JULY 2022
  "Introduction to Artificial Intelligence and (Tiny)ML"
  EASI-22: The 2022 Edge AI Summer Institute, Remote
- "Convolutions and Transfer Learning for Computer Vision" JULY 2022
  "The Future of Machine Learning is Tiny and Bright"
  SciTinyML-22 Latam: Latin America Regional Workshop on Scientific Use of Machine Learning on Low-Power Devices Workshop, Remote
- "Data Pre-Processing for Hands-on Keyword Spotting" APR 2022
  "Convolutions for Hands-on Computer Vision"
  SciTinyML-22 Africa: African Regional Workshop on Scientific Use of Machine Learning on Low-Power Devices, Remote
- "TinyMLedu: Widening Access to TinyML Education and Resources" JAN 2022
  TinyML Toronto Meetup, Remote
- "Hardware Acceleration for Realtime Robotics" DEC 2021
  Barnard College, New York, NY, USA
- "Introduction to Robot Motion Planning" DEC 2021
  Simmons College, Boston, MA, USA
- "TinyMLedu Outreach: Embedded Machine Learning for the Navajo Nation" NOV 2021
  TinyML for Good, Remote
- "Hands-on Embedded ML from Theory to Practice: Vision and Audio" OCT 2021
  SciTinyML-21: Scientific Use of Machine Learning on Low-Power Devices Workshop, Remote
- "Robust Realtime Model Predictive Control through Co-Design" DEC 2020
  Carnegie Mellon University, Robotic Exploration Lab, Remote
- "Custom Accelerator Chips (ASICs) for Robotics / Autonomous Systems" APR 2020
  Pillar VC, Boston, MA, USA
- "Accelerating Real Time Model Predictive Control" OCT 2019
  Optimus Ride, Boston, MA, USA
- "GPU Acceleration for Robotics" NOV 2018
  DUT/MIT Formula Student Driverless, Cambridge, MA, USA

UNIVERISTY COMMITTESS

Barnard College, Columbia University:
- Barnard College Summer Research Institute Department Representative for Computer Science 2022 – PRESENT
- Barnard Center for Research on Women (BCRW) Faculty Advisory Board 2022 – PRESENT
- Barnard College Computer Science Faculty Search Committee FALL 2024
- Columbia University Robotics Faculty Search Committee – Affiliate Member SPRING 2024
- Barnard College Computer Science Tenured Faculty Search Committee FALL 2023

Harvard University:
- Harvard Women in STEM ENVISION Proposal-Writing Competition Judges Panel 2021-2022
- SEAS Committee on Diversity, Inclusion, and Belonging: Post-Baccalaureate Outreach Working Group 2021
- Harvard i3: The Harvard College Innovation Challenge Judges Panel 2021

OUTREACH AND PROFESSIONAL SERVICE

ORGANIZATIONAL LEADERSHIP

- The Tiny Machine Learning Open Education Initiative (TinyMLedu) [Link]: *Co-Chair:* 2021 – PRESENT
  - Additionally named to the TinyML Foundation Industry-Academia Leadership Team in August 2024 [Link]
- IEEE RAS Technical Committee on Model-Based Optimization for Robotics [Link]: *Associate Co-Chair:* 2022 – PRESENT
  - Won the "Blue Ribbon TC Award" in 2023 (formerly the "Most Active TC Award")

WORKSHOP AND SPECIAL SESSION CO-ORGANZIER

- RoboARCH 2022-25: Workshop on Robotics Acceleration with Computing Hardware and Systems. This workshop was held both as an IEEE/ACM International Symposium on Microarchitecture (MICRO) Workshop [Link-22, 23, 24] and as an IEEE International Conference on Robotics and Autonomation (ICRA) Workshop [Link-25].
- SciTinyML 2021-24: Scientific Use of Machine Learning on Low-Power Devices. a 5-day hands-on, virtual workshop for university students and professors exploring real-world applications of TinyML and their impact on the developing world. 2021 was run globally with 216 participants from 48 countries, 2022 was run regionally for Africa (187 from 29), Asia (100 from 8), and Latin America (200 from 17), 2023-24 were run globally (418 from 76 and 201 from 44) [Link-21, 22, 23, 24].
- Special Session on Tiny Machine Learning at the 2025 International Joint Conference on Neural Networks [Link].
- Workshop on TinyML for Sustainable Development 2024. An in-person, 5-day, hands-on workshop co-organized and hosted by IBM in Sao Paulo, Brazil focused how TinyML can be leveraged for the benefit of all globally [Link].
- Workshop on Leveraging Models for Contact-Rich Manipulation. An IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) 2023 Workshop [Link].
- EdgeMLUP 2023: Workshop on Widening Access to TinyML Network by Establishing Best Practices in Education. An in-person, 5-day, hands-on workshop at ICTP for university level educators, focused on the global south, to develop and expand access to embedded machine learning curricula and research programs [Link].
- 3rd On-Device Intelligence Workshop. A Conference on Machine Learning and Systems (MLSys) 2023 Workshop. [Link]
- Building Approachable, Hands-On Embedded Machine Learning Curriculum Using Edge Impulse and Arduino. An AAAI 2023 Conference on Artificial Intelligence Tutorial and Lab Forum [Link].
- Mind the Gap: Opportunities and Challenges in the Transition Between Research and Industry. A Robotics Science and Systems (RSS) 2022 Workshop [Link].
- EASI 2022: the Edge AI Summer Institute. A 3-day, hands-on workshop for high school teachers and students serving the Navajo Nation exploring artificial intelligence through hands-on examples of TinyML. This program was a collaboration between Harvard University, Navajo Technical University and Barnard College, Columbia University [Link].
- CRESTLEX 2021: CReating Effective STem Learning Experiences. A 4-day, hands-on workshop for high school teachers and students serving the Navajo Nation exploring artificial intelligence through hands-on examples of TinyML. This program was a collaboration led by Harvard and Navajo Technical University with support from Google and Edge Impulse [Link].

ASSOCIATE EDITOR / PROGRAM COMMITTEE:

- IEEE Robotics and Automation Letters (RAL) – Humanoids and Animaloids: 2024 – PRESENT
- IEEE International Conference on Humanoid Robots (Humanoids): 2024
- IEEE International Conference on Simulation for Modeling and Programming for Autonomous Robots (SIMPAR): 2025
- TinyML Research Symposium: 2025

SESSION CHAIR:

- Reinforcement Learning I at the 2024 IEEE International Conference on Robotics and Automation (ICRA)

GRANT PANELIST:

- NSF CISE Review Panels: 2024

REVIEWER:

- IEEE Transactions on Robotics (T-RO): 2023
- IEEE Transactions on Control Systems Technology (TCST): 2023
- IEEE Robotics and Automation Letters (RAL): 2019
- IEEE Micro: 2023
- IEEE International Conference on Robotics and Automation (ICRA): 2021-23, 25
- IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS): 2020, 22-24
- Robotics Science and Systems (RSS): 2023-24
- IEEE Conference on Decision and Control (CDC): 2024
- IFAC Conference on Nonlinear Model Predictive Control (NMPC): 2024
- Conference on Neural Information Processing Systems (NeurIPS): Datasets and Benchmarks Track 2023, 24
- ACM Innovation and Technology in Computer Science Education (ITiCSE): 2022-24
- ACM Technical Symposium on Computer Science Education (SIGCSE TS): Posters 2023, APC Posters 2024, Papers 2025
- IEEE International Conference on Advanced Motion Control (AMC): 2022

- IEEE Integrated STEM Education Conference (ISEC): 2018
- UN IATT STI Forum: 2023

PROFESSIONAL SOCIETY MEMBERSHIP

- Institute of Electrical and Electronics Engineers (IEEE)
- IEEE Robotics and Automation Society (IEEE-RAS)
- IEEE-RAS Technical Community (TC) on Model-Based Optimization for Robotics (TCOptRob), TC on Humanoids, TC on Performance Evaluation & Benchmarking, TC on Robot Learning, TC on Robot Ethics
- IEEE Computer Society (IEEE-CS)
- IEEE-CS Technical Community (TC) on Parallel Processing (TCPP)
- IEEE Women in Engineering (IEEE-WiE)
- Association for Computing Machinery (ACM)
- ACM Special Interest Group on Computer Science Education (ACM-SIGCSE)
- Association for the Advancement of Artificial Intelligence (AAAI)
- Institute for Operations Research and the Management Sciences (INFORMS)
- Society for Industrial and Applied Mathematics (SIAM)
- Women in AI & Robotics

ADDITONAL PROFESSIONAL EXPERIENCE

PILLAR VC: Boston, MA – *Venture Fellow*   JAN 2020 - MAY 2020
- Assisted in sourcing and evaluating potential investments with a focus in robotics and AI

MCKINSEY & COMPANY: Boston, MA – *Business Analyst*   AUG 2013 - JULY 2015
- Offered promotion to senior associate (designation reserved for top ~5% of business analyst class)
- On multiple projects, played "junior engagement manager" role, project managing newer business analysts
- Led product development strategy for a software product, interfacing between multiple engineering teams and management at the business unit and corporate levels for a prime defense contractor
- Analyzed the value chain, market dynamics, and entry strategy for a new product for a high-tech materials manufacturer
- Led business case and market entry strategy development for a novel aircraft for a major aerospace manufacturer
- Designed a network deployment and capital planning strategy for a national wireless carrier
- Facilitated a culture transformation for a Fortune 500 company including a simultaneous worldwide conference
- Designed a comprehensive economic development and revitalization strategy for a rural area of the United States
- Performed the strategic due diligence that led to a successful large (>$10Bn) deal between Fortune 500 companies

UNITED STATES DEPARTMENT OF DEFENSE: Fort Meade, MD – *Cryptologic Access Program*   MAY 2012 - AUG 2012
- Led an internal consulting project on the use of Cloud-based solutions by developing a Map-Reduce Analytic backed GUI prototype and researching and presenting findings on possible use cases to division management
- Helped lead weekly meetings to coordinate a 15 person development team and ensure code reuse and efficient production
- Designed and built generic and reusable widgets in EXT-JS and the Ozone Widget Framework in order to aid leadership in analyzing current operational metrics and improve operational efficiency and oversight

US GREEN DATA: Cambridge, MA – *Senior Software Engineer*   SEPT 2011 - MAY 2012
- Managed the tech team consisting of 4 Harvard Students and 4 professional web developers to ensure collaboration and production as lead web designer and developer in a Django / jQuery environment
- Evaluated the web development direction, product line and client requirements with the CEO and other company leaders
- Worked with the consulting team to create data models to improve data analysis efficiency and maximize client savings
- Provided system administrator function to maintain and improve the web architecture, security and design

REFERENCES