Yijiang Huang

Postdoctoral fellow at ETH Zurich

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Research interests

Computational planning methods that coordinate robots, humans, and resources to enable the efficient construction of sustainable structural solutions.

Education

9/2018 - 9/2022 Ph.D. in Building Technology — Department of Architecture, MIT
Dissertation: *Algorithmic planning for robotic assembly of building structures*
Advised by Caitlin Mueller
MIT Presidential fellow (2018)

9/2016 - 5/2018 Master of Science in Building Technology — Department of Architecture, MIT
Thesis: *Automated motion planning for robotic assembly of discrete architectural structures*
Advised by Caitlin Mueller
MIT Presidential fellow (2016)

9/2012 - 5/2016 Bachelor of Science in Applied Mathematics — University of Science and Technology of China

Research Experience

1/2023 - Now Postdoctoral fellow — Computational Robotics Lab, ETH Zurich
Developed a computational design framework for spatial bar structures with reusable swivel coupler joints; researched planning and control for cooperative mobile robotic assembly; contributed to cross-departmental research for NCCR DFAB. Supervised by Stelian Coros.

9/2016 - 8/2022 Graduate research assistant — Digital Structures Group, MIT
Developed planning algorithms for robotic assembly and tested them on real-world robot systems in various physical scales; developed computational matching algorithms for circular design with reused materials; collaborated with researchers at MIT, Princeton, TU Delft and ETH Zurich; published results in journal and presented findings at academic conferences and seminars; led instructions and contributed to the developments of various courses and workshops. Advised by Caitlin Mueller.

6/2019 - 8/2019 Guest researcher — Gramazio & Kohler Research Group, ETH Zurich
Integrated robotic planning algorithms to the open-source COMPAS-FAB framework; led hands-on workshops about the developed software.

2/2015 - 6/2016 Undergraduate research assistant — Geometry and Graphics Computing Lab, USTC
Developed a sequence planning algorithm for robotic spatial extrusion; designed and built a customized extrusion hardware; led a collaboration with an architectural firm's R&D branch; published results at SIGGRAPH Asia. Advised by Juyong Zhang, Lei Yu, and Ligang Liu.

Professional Experience

9/2020 - 5/2021 **Remote technical consultant** — Roboticplus Inc., virtual
Bi-weekly remote meetings with the R&D team to provide technical advice on geometric feature detection, point cloud registration, and path planning of wood-cutting and welding robots.

7/2015 - 8/2016 **Research intern** — ArchiSolution Workshop, Beijing
Research stay to develop collaborated academic research project on robotic extrusion planning. Contributed to the assembly of large-scale 3D printers. Monitor the fabrication and shipping process of a commercial 3D printed facade. Developed a robotic layer-based printing demo for clients.

Fellowships and Funding

1/2023-1/2025 ETH Zurich Postdoctoral Fellowship
208,900 CHF in salary costs + 24,000 CHF for research and travel costs, awarded to 15 individuals each year (25% success rate).

9/2016, 9/2018 MIT Presidential Fellowship
Funding for tuition (50k USD each year) and living stipend of one academic year (48k USD), with additional guaranteed TA funding coverage throughout the entire duration of study if needed. Awarded to around 110 new graduate students each year (out of 7,200 grads), selected by the Deans and Heads of Departments at MIT.

9/2014 - 6/2016 USTC Outstanding Undergraduate Student Scholarship (500 RMB/year)

Publications

* indicates authors contributed equally.

Journal articles

2023 SMO M. Tarek and **Y. Huang**
General deflation for finding multiple local optima in non-convex optimization
Structural and Multidisciplinary Optimization, 2023, in press

2023 Siggraph Z. Wang, F. Kennel-Maushart, **Y. Huang**, B. Thomaszewski, S. Coros
A Temporal Coherent Topology Optimization Approach for Assembly Planning of Bespoke Frame Structures
ACM Transactions on Graphics (TOG), 2023, 42.4, pp 1-13

2021 ConRob **Y. Huang**, C. Garrett, I. Ting, S. Parascho, C. Mueller
Robotic additive construction of bar structures: Unified sequence and motion planning
Construction Robotics, vol. 5, pp. 115-130

2018 ConRob **Y. Huang**, C. Garrett, C. Mueller
Automated sequence and motion planning for robotic spatial extrusion of 3D trusses
Construction Robotics, vol. 2, no. 1-4, pp. 15-39

2017 IJRM K. Tam, D. Marshall, M. Gu, J. Kim, **Y. Huang**, J. Lavallee, C. Mueller
Fabrication-aware structural optimisation of lattice additive-manufactured with robot-arm

International Journal of Rapid Manufacturing, vol. 7, no. 2-3, pp. 120-168

2016 Siggraph **Y. Huang**, J. Zhang, X. Hu, G. Song, Z. Liu, L. Yu, L. Liu
Framefab: Robotic fabrication of frame shapes
ACM Transactions on Graphics (TOG), 35(6), 224

Conference articles

2021 SCF **Y. Huang**, V.P.Y. Leung, C. Garrett, F. Gramazio, M. Kohler, C. Mueller
The new analog: A protocol for linking design and construction intent with algorithmic planning for robotic assembly of complex structures
Proceedings of ACM Symposium on Computational Fabrication, 2021

2021 SCDoS **Y. Huang**, L. Alkhayat, C. De Wolf, C. Mueller
Algorithmic circular design with reused structural elements: Method and Tool
Proceedings of the international FIB symposium of Conceptual Design of Structures, 2021

2020 RSS C. Garrett*, **Y. Huang***, T. Lozano-Pérez, C. Mueller
Scalable and Probabilistically Complete Planning for Robotic Spatial Extrusion
Proceedings of Robotics: Science and Systems (RSS), virtual, 2020

2020 AAG F. Amtsberg*, **Y. Huang***, D. Marshall, K. Gata, C. Mueller
Structural upcycling: Matching digital and natural geometry
Proceedings of Advances in Architectural Geometry, Champs-sur-Marne, France, 2020

2019 SCF R. Arora, A. Jacobson, T. Langlois, **Y. Huang**, C. Mueller, W. Matusik, A. Shamir, K. Singh, D. Levin
Volumetric Michell trusses for parametric design & fabrication
Proceedings of the ACM Symposium on Computational Fabrication, 2019

2019 ACADIA L. Tessmer, **Y. Huang**, C. Mueller
Additive Casting of Mass-Customizable Bricks: Workflow for Design and Robotic Fabrication
Proceedings of the 39th Annual Conference of the Association for Computer Aided Design in Architecture (ACADIA), Austin, Texas, 21-26 October, 2019

2018 RobArch **Y. Huang**, J. Carstensen, L. Tessmer, C. Mueller
Robotic extrusion of architectural structures with nonstandard topology
Proceedings of Robotic Fabrication in Architecture, Art and Design (RobArch), 2018

2018 IASS **Y. Huang**, J. Carstensen, C. Mueller
3D truss topology optimization for automated robotic spatial extrusion
Proceedings of International Association for Shell and Spatial Structures (IASS), Boston, MA, 2018

2016 ACADIA L. Yu, **Y. Huang**, Z. Liu, S. Xiao, L. Liu, G. Song, Y. Wang
Highly Informed Robotic 3D Printed Polygon Mesh: A Novel Strategy of 3D Spatial Printing
Proceedings of the 36th Annual Conference of the Association for Computer Aided Design in Architecture (ACADIA), Ann Arbor 27-29 October, 2016, pp. 298-307

Workshop articles

2020 IROS C. Garrett*, **Y. Huang***, T. Lozano-Pérez, C. Mueller
Scalable Planning for Robotic Spatial Extrusion
IROS Workshop on Building Construction and Architecture Robotics, online, 2020.

Preprints

2023 K. Doshi, **Y. Huang**, S. Coros
On Hand-Held Grippers and the Morphological Gap in Human Manipulation Demonstration

2022 J. Chen, J. Li*, **Y. Huang***, C. Garrett, D. Sun, C. Fan, A. Hofmann, C. Mueller, S. Koenig, B. Williams
Cooperative Task and Motion Planning for Multi-Arm Assembly Systems

Conference abstracts and Posters

2023 FoC Y.H. Hung*, C. Jiang*, Z. Wang, **Y. Huang**, A.L. Gheyselinck, P. Aejmelaeus-Lindström
Computational Design and Assembly of Infinitely Reusable Kit of Parts
Future of Construction Symposium, Munich, Germany, 2023

2023 IRS K.J. Lee, **Y. Huang**, C. Mueller
A differentiable assignment algorithm for high performance inventory-driven structural design
(In)visible Reuse Symposium, Lausanne, Switzerland, 2023

2021 WCSMO **Y. Huang** and M. Tarek
TopOpt.jl: Truss and Continuum Topology Optimization, Interactive Visualization, Automatic Differentiation and More
In: *14th World Congress of Structural and Multidisciplinary Optimization (WCSMO-2021)*

Selected Software

Open-source code is available on my website for most of the publications above.

COMPAS-FAB — Contributor
A Python package for the COMPAS Framework that facilitates the planning and execution of robotic fabrication processes

pybullet_planning — Contributor
A Python package based on the pybullet physics simulation engine to provide collision checking, kinematics, and motion planning for robotics research.

ikfast_pybind — Author
A Python package for analytical robot kinematics.

conmech — Author
A Python package for linear elastic analysis of spatial trusses and frames.

TopOpt.jl — Contributor
A Julia package for flexible topology optimization on continuum and truss domains.

Professional Service

External Reviewing

Journal and Conferences

2018-2023 Construction Robotics
2019 ACM SIGGRPAH
2020 ACM SIGGRAPH Asia
2020-2021 ACM Symposium of Computational Fabrication

Grants

2023 Review Panel for ETH Zurich Career Seed Awards

Teaching

Semester-long courses

2019-2021 Computational Structural Design and Optimization (4.450) MIT Architecture
Teaching assistant ($\sim$ 25 students per year)
Led weekly office hours and monitored student final projects; developed new assignments and lectures to reflect recent developments and tools in optimization and fabrication; guest lecture on optimization algorithms and discrete and combinatorial optimization. (with C. Mueller)

Spring 2018 Design for Robotic Assembly (4.S48) MIT Architecture
Instructor (12 students)
Designed, organized, and presented a new project-based course on architectural design for robotic assembly. Students learned the basic principles of programming an industrial robotic arm and explored creative usage of the technology. Their final projects questioned the physical precision of robots, engaged in playful human-robot interactions, and produced bespoke geometries. (with C. Mueller and J. Lavallee)

Workshops

10/2023 Task and Motion Planning for Robotic Assembly ACADIA, hybrid
Co-instructor (17 students, three-day-long workshop)
Gave lectures and led tutorial sessions. Students used the robot planning tool developed in my research to generate robot assembly program for assemblies they designed. (with V.P.Y. Leung)

7/2020 Kintsugi, Upcycling, and Machine Learning (4.181) MIT Architecture
Co-instructor (12 students, three-week-long workshop)
Gave lectures and led tutorial sessions. Students used the optimal matching tool developed in my research to design new assemblies from recycled materials. (with C. Mueller, D. Marshall, D. White)

10/2019 Fabrication-informed design of robotically assembled structures Design Modeling Symposium, Berlin
Co-instructor (14 students, two-day-long workshop)
Gave lectures and tutorials. Students used the planning system developed in my research to compute robot trajectories to assemble structures they designed. (with S. Parascho, G. Wartinger, C. Mueller)

9/2019 Structural Upcycling workshop MIT Architecture
Co-instructor (10 students, two-week-long workshop)
Developed computational design workflow for designing structures that reuse recycled tree branches. (with F. Amtsberg, D. Marshall, K.M. Gata, C. Mueller)

7/2017 Parametric Architectural Design Workshop Tsinghua University, Beijing
Teaching Assistant (13 students, one-week-long workshop)
Mentored students on the design and construction of full-scale, load-bearing bridges, using generative computational design tools that link architectural expression with structural performance. (with C. Mueller)

7/2016 Parametric Architectural Design Workshop — Tsinghua University, Beijing
Teaching Assistant (12 students, one-week-long workshop)
Mentored students on the use of industrial robots to cut customized wood notches for the assembly of a human-scale reciprocal wood vault. (with L. Yu and Z. Liu)

Anonymous Teaching Feedback

Fall 2019-2021 Computational Structural Design and Optimization (4.450) — MIT Architecture
A sample of anonymous feedback about my teaching assistantship is gathered below, where each quotation corresponds to a different student:
"Yijiang has been the best TA I have had at MIT. He's thoughtful and thorough in his responses and feedback and seems to have a true passion for the material. Couldn't have succeeded in this course without him."
"Yijiang had a very challenging job as a (sole) TA to ∼31 students! He was always responsive over email and Piazza. It's nice to know that no matter what, I could count on getting an answer to any question that came up. Yijiang is also very kind and thoughtful, and I was never worried to ask him questions in class. Great TA."
"Yijiang is the best TA that I've ever had. He is so helpful and so passionate about the subject. He is so approachable and he answers questions so quickly and in such an understandable manner."
"Amazing TA. I've learnt a lot from Yijiang and he definitely goes out of his way to help us, be it during or out of class. Really fortunate to have him as the teaching assistant for the class."

Mentoring

Master's Thesis Advisor

11/2023 - now Peiyu Zeng — ETH Zurich
Master in Robotics, Systems, and Control (ME). Thesis: Computational design of automated logistic factories (with S. Huber and S. Coros)

5/2023 - 9/2024 Yi Hsiu Hung, Chenming Jiang — ETH Zurich
Master in Digital Fabrication (Architecture). Thesis: Computational Design and Assembly of Infinitely Reusable Kit of Parts (with Z. Wang, A. Gheyselinck, P. Aejmelaeus-Lindström)

Academic Year Undergraduate Researchers

2017 Thomas Cook — MIT EECS Senior
Industrial robot's planning and simulation

2017 Kodiak Brush — MIT ME Senior
Thermal hotend design for robotic printing

2017 Khanh Nguyen — MIT ME Sophomore
Portable 3D printing control system design

External committee member

2/2023 Gabriel Vallat — EPFL
Master thesis: Multi-agent Reinforcement Learning for Assembly of a Spanning Structure (with M. Kamgarpour and S. Parascho)

Summer Undergraduate and High School Researchers

8/2021 Research mentor, Summer Geometry Institute — Virtual, MIT
Bonnie Magland, Cynthia Fan, Lily Kimble, Marcus Vidaurri
Planned, prepared, and mentored a week-long research project for four undergraduate students (1 ME, 2 CS, 1 Math) on design optimization via shape morphing. (with C. Mueller)

8/2020 Mentor, HerCodeCamp — Virtual, UToronto
Mentored four female-identified high-school students on a two-week-long code camp to build a ping-pong game in Python. (with N. Sultanum)

Press

5/2022 MIT engineers build load-bearing structures using tree forks instead of steel joints — Dezeen
3/2022 Using nature's structures in wooden buildings — MIT News

Invited Seminar Talks

10/2023 AsiaGraphics Webinar — Online
7/2023 USTC computer graphics summer school — USTC
6/2023 Applied R&D at Foster + Partners — London
5/2023 Design++ seminar series — ETH Zurich
10/2022 Mark Pauly's group — EPFL
11/2021 Justin Solomon's group — MIT
11/2021 Stefanie Mueller's group — MIT
10/2020 Young series: Robotic Fabrication 3 — DigitalFUTURES
6/2020 Intelligent Autonomous Systems Seminar — TU Darmstadt
9/2019 Guest lecture at Modeling and Analysis of Structures (1.571) — MIT
4/2019 AIR Seminar of the Hariri Institute of Computing — Boston University
3/2018 Disney Research Zurich — Disney
3/2018 Institute of Technology in Architecture — ETH Zurich
11/2017 Simple Person's Applied Math Seminar (SPAMS) — MIT
11/2017 Computer Graphics Seminar — MIT
4/2017 Brian Williams's group — MIT

Athletics Program Involvement

2022-present Member of Nestlé FC — Vevey, CH
2022-2023 Member of Vevey Sport FC 3rd team — Vevey, CH
2017-2022 Member of BKP FC — Boston
2016-2022 Member and captain (2019) of Chinese Scholar and Student Association (CSSA) Soccer Team — MIT