

Hongwei Cai

Department of Intelligent Systems Engineering
Indiana University Bloomington
Email: hw.cai.mail@gmail.com

Research Interests

- Intelligent human organoid microphysiological systems
- Organoid neural interface and biohybrid intelligence
- AI-enabled biomedical devices for precision medicine and healthcare

Education and Training

- 2026-present:** Postdoctoral Fellow, Department of Intelligent Systems Engineering, Indiana University Bloomington. Advisor: Prof. Feng Guo.
- 2018-2025:** Ph.D. in Intelligent Systems Engineering, Indiana University Bloomington. Thesis: *Intelligent Brain Organoid Microphysiological Systems*. Advisor: Prof. Feng Guo.
- 2014-2018:** B.S. in Acoustics, Nanjing University, China.

Research Experience

- 2018-present:** Indiana University Bloomington, Department of Intelligent Systems Engineering. Advisor: Prof. Feng Guo. Research focus: intelligent brain organoid microphysiological systems, organoid neural interfaces and biohybrid intelligence, and AI-enabled biomedical devices for precision medicine.

Intelligent human organoid microphysiological systems for disease modeling and preclinical testing

- Developed vascular network-inspired diffusible scaffolds integrated with microelectrode arrays (MEAs) for generating functional midbrain organoids with minimal hypoxia and physiologically relevant pharmacological response. (*Cell Stem Cell*, 2025, highlighted by *Cell Biomaterials*, one U.S. patent)
- Developed flattened organoid-on-a-chip systems for plug-and-play in-situ neural activity measurements and modeling opioid tolerance. (*Bioactive Materials*, 2023, one U.S. patent)
- Developed an intelligent acoustofluidics mini-bioreactor for automated organoid culture with stable rotational flow. (*Lab on a Chip*, 2021, one U.S. patent)

Organoid neural interface and biohybrid intelligence

- Developed **Brainware**: a biohybrid brain organoid reservoir computing platform through a MEA neural interface, performing real-world AI tasks such as speech recognition and solving nonlinear equations with minimal training. (*Nature Electronics*, 2023, reported by over 140 media outlets worldwide including Nature News, MIT Technology Review, GEN, Daily Mail Online, ScienceAlert; one U.S. patent)
- Developed **Brainobot**: organoid biohybrid computing for closed-loop embodiment of “sense-decision-action” and decision-making in real-world tasks such as navigating and grasping. (*Nature Electronics*, under review)

AI-enabled biomedical devices for precision medicine and healthcare

- Developed AI-guided microfluidics platforms for automated imaging and high-throughput T-cell infiltration-based cancer immunotherapy screening. (*PNAS*, 2022, one U.S. patent)
- Developed an AI-enabled closed-loop therapeutic system integrating sensors, AI detection, and a digital wearable acoustofluidic patch for automated, on-demand drug delivery and precision reversal of anaphylaxis and opioid overdose. (*Nature Communications*, 2023 and accepted; three U.S. patents)

Publication Summary

- 30** publications
- 11** first-authored (co-first) publications
- 11** U.S. patents or patent applications, including **4** granted patents
- 4** papers featured as cover stories
- Citation count: **2277**; H-index: **24** on Google Scholar as of September 1, 2026

First-Authored Publications

- H. Cai**, C. Tian, K. Mackie, and F. Guo*. “Interfacing biological neural networks with three-dimensional devices.” *Nature Electronics*, 9(5): 461–462, 2026. News & Views.
- H. Cai**, C. Tian, L. Chen, Y. Yang, A. X. Sun, K. McCracken, J. Tchieu, M. Gu, K. Mackie, and F. Guo*. “Vascular network-inspired diffusible scaffolds for engineering functional midbrain organoids.” *Cell Stem Cell*, 32(5):824-837.e825, 2025. Highlighted by *Cell Biomaterials*.
- H. Cai**, Z. Ao, C. Tian, Z. Wu, H. Liu, J. Tchieu, M. Gu, K. Mackie, and F. Guo*. “Brain organoid reservoir computing for artificial intelligence.” *Nature Electronics*, 6(12):1032-1039, 2023. Highlighted by *Nature Electronics* and reported by more than 140 media outlets worldwide.
- H. Cai**, Z. Ao, C. Tian, Z. Wu, C. Kaurich, Z. Chen, M. Gu, A. G. Hohmann, K. Mackie, and F. Guo*. “Engineering human spinal microphysiological systems to model opioid-induced tolerance.” *Bioactive Materials*, 22:482-490, 2023.
- J. Xu#, **H. Cai**#, Z. Wu, X. Li, C. Tian, Z. Ao, V. C. Niu, X. Xiao, L. Jiang, M. Khodoun, M. Rothenberg, K. Mackie, J. Chen, L. P. Lee, and F. Guo*. “Acoustic metamaterials-driven transdermal drug delivery for rapid and on-demand management of acute disease.” *Nature Communications*, 14(1):869, 2023. #Equal contribution.
- Z. Ao#, **H. Cai**#, Z. Wu, L. Hu, A. Nunez, Z. Zhou, H. Liu, M. Bondesson, X. Lu, X. Lu, M. Dao, and F. Guo*. “Microfluidics guided by deep learning for cancer immunotherapy screening.” *Proceedings of the National Academy of Sciences*, 119:e2214569119, 2022. #Equal contribution.
- Z. Ao#, **H. Cai**#, Z. Wu, J. Ott, H. Wang, K. Mackie, and F. Guo*. “Controllable fusion of human brain organoids using acoustofluidics.” *Lab on a Chip*, 21(4):688-699, 2021. Back cover. #Equal contribution.
- H. Cai**, Z. Ao, Z. Wu, S. Song, K. Mackie, and F. Guo*. “Intelligent acoustofluidics enabled mini-bioreactors for human brain organoids.” *Lab on a Chip*, 21:2194-2205, 2021.
- H. Cai**, Z. Ao, L. Hu, Y. Moon, Z. Wu, H.-C. Lu, J. Kim, and F. Guo*. “Acoustofluidic assembly of 3D neurospheroids to model Alzheimer’s disease.” *Analyst*, 145:6243-6253, 2020. Cover story.
- H. Cai**, Z. Wu, Z. Ao, A. Nunez, B. Chen, L. Jiang, M. Bondesson, and F. Guo*. “Trapping cell spheroids and organoids using digital acoustofluidics.” *Biofabrication*, 12:035025, 2020.
- H. Cai**, Z. Ao, Z. Wu, A. Nunez, L. Jiang, R. Carpenter, K. Nephew, and F. Guo*. “Profiling cell-matrix adhesion using digitalized acoustic streaming.” *Analytical Chemistry*, 92:2283-2290, 2020.

Collaborative Publications

- Y. Xing, Y. Yang, Z. Hong, C. Tian, H. Chu, S. C. Prokop, **H. Cai**, M. Gu, J. Tchieu, K. Mackie, and F. Guo*. “Organoid brain-machine-interface devices for central nervous system repair.” *Advanced Science*, e75444, 2026.
- C. Tian, Z. Ao, J. Cerneckis, **H. Cai**, L. Chen, H. Niu, K. Takayama, J. Kim, Y. Shi, and F. Guo*. “Understanding monocyte-driven neuroinflammation in Alzheimer’s disease using human cortical organoid microphysiological systems.” *Science Advances*, 11(34):eadu2708, 2025.
- X. Li, J. Chen, Y. Yang, **H. Cai**, Z. Ao, Y. Xing, K. Li, K. Yang, W. Guan, and F. Guo*. “Extracellular vesicle-based point-of-care testing for diagnosis and monitoring of Alzheimer’s disease.” *Microsystems & Nanoengineering*, 11(1):65, 2025.
- K. Li, L. Gu, **H. Cai**, H.-C. Lu, K. Mackie, and F. Guo*. “Human brain organoids for understanding substance use disorders.” *Drug Metabolism and Pharmacokinetics*, 101031, 2025.
- C. Tian, **H. Cai**, Z. Ao, L. Gu, X. Li, V. C. Niu, M. Bondesson, M. Gu, K. Mackie, and F. Guo*. “Engineering human midbrain organoid microphysiological systems to model prenatal PFOS exposure.” *Science of The Total Environment*, 947:174478, 2024.
- L. Gu, **H. Cai**, L. Chen, M. Gu, J. Tchieu, and F. Guo*. “Functional neural networks in human brain organoids.” *BME Frontiers*, 5:0065, 2024.
- Z. Wu, **H. Cai**, C. Tian, Z. Ao, L. Jiang, and F. Guo*. “Exploiting sound for emerging applications of extracellular vesicles.” *Nano Research*, 17(2):462-475, 2024.
- Z. Wu, Z. Ao, **H. Cai**, X. Li, B. Chen, H. Tu, Y. Wang, R. O. Lu, M. Gu, and F. Guo*. “Acoustofluidic assembly of primary tumor-derived organotypic cell clusters for rapid evaluation of cancer immunotherapy.” *Journal of Nanobiotechnology*, 21(1):1-9, 2023.
- Z. Ao, S. Song, C. Tian, **H. Cai**, X. Li, Y. Miao, Z. Wu, J. Krzesniak, B. Ning, and F. Guo*. “Understanding immune-driven brain aging by human brain organoid microphysiological analysis platform.” *Advanced Science*, 9(27):2200475, 2022.
- Z. Ao, Z. Wu, **H. Cai**, L. Hu, X. Li, C. Kaurich, J. Chang, M. Gu, L. Cheng, X. Lu, and F. Guo*. “Rapid profiling of tumor-immune interaction using acoustically assembled patient-derived cell clusters.” *Advanced Science*, 2201478, 2022.
- Z. Ao, **H. Cai**, Z. Wu, L. Hu, X. Li, C. Kaurich, M. Gu, L. Cheng, X. Lu, and F. Guo*. “Evaluation of cancer immunotherapy using mini-tumor chips.” *Theranostics*, 12(8):3628-3636, 2022. Cover story.
- Z. Ao, **H. Cai**, Z. Wu, J. Krzesniak, C. Tian, Y. Lai, K. Mackie, and F. Guo*. “Human spinal organoid-on-a-chip to model nociceptive circuitry for pain therapeutics discovery.” *Analytical Chemistry*, 94(2):1365-1372, 2022.
- Z. Wu, **H. Cai**, Z. Ao, J. Xu, S. Heaps, and F. Guo*. “Microfluidic printing of tunable hollow microfibers for vascular tissue engineering.” *Advanced Materials Technology*, 2000683, 2021.
- Z. Ao, **H. Cai**, Z. Wu, S. Song, H. Karahan, B. Kim, H.-C. Lu, J. Kim, K. Mackie, and F. Guo*. “Tubular human brain organoids to model microglia-mediated neuroinflammation.” *Lab on a Chip*, 21:2751-2762, 2021.
- Z. Wu, Z. Gong, Z. Ao, J. Xu, **H. Cai**, M. Muhsen, S. Heaps, M. Bondesson, S.-S. Guo, and F. Guo*. “Rapid microfluidic formation of uniform patient-derived breast tumor spheroids.” *ACS Applied Biomaterials*, 3:6273-6283, 2020.
- Z. Ao, **H. Cai**, D. Havert, Z. Wu, Z. Gong, J. Beggs, K. Mackie, and F. Guo*. “One-stop microfluidic assembly of human brain organoids to model prenatal cannabis exposure.” *Analytical Chemistry*, 92(6):4630-4638, 2020.
- Z. Wu, **H. Cai**, Z. Ao, A. Nunez, H. Liu, M. Bondesson, S.-S. Guo, and F. Guo*. “A digital acoustofluidic pump powered by localized fluid-substrate interactions.” *Analytical Chemistry*, 91:7097-7103, 2019.
- J. Xu, R. Danehy, Z. Ao, **H. Cai**, M. Pu, A. Nusawardhana, D. Rowe, and F. Guo*. “Microneedle patch-mediated treatment of bacterial biofilms.” *ACS Applied Materials & Interfaces*, 11:14640-14646, 2019.
- B. Chen, Y. Wu, Z. Ao, **H. Cai**, A. Nunez, Y. Liu, J. Foley, K. Nephew, X. Lu, and F. Guo*. “High-throughput acoustofluidic fabrication of tumor spheroids.” *Lab on a Chip*, 19:1755-1763, 2019.

Patents

Granted

- F. Guo, J. Xu, and **H. Cai**. “Systems and methods for microneedle therapeutic delivery with acoustic signals.” U.S. Patent 12,721,986.
- F. Guo and **H. Cai**. “Methods and systems for dynamic control of an acoustic field.” U.S. Patent 12,649,133.
- F. Guo, Z. Ao, and **H. Cai**. “Methods for identifying and using cell behavior in drug screening and diagnosis.” U.S. Patent 12,456,194.
- F. Guo, Z. Ao, and **H. Cai**. “Open chamber acoustic device to measure cell binding force.” U.S. Patent 12,158,423.

Filed

- F. Guo and **H. Cai**. “Perfusable scaffolds for 3D cell cultures and methods of use.” U.S. Patent App. 19/252,737.
- F. Guo, K. Mackie, and **H. Cai**. “Intelligent closed-loop system for real-time reversal of acute disease.” U.S. Patent App. PCT/US2025/017276.
- F. Guo, **H. Cai**, and K. Mackie. “Acoustofluidic patch for sampling and delivery.” U.S. Patent App. 19/252,811.
- F. Guo, **H. Cai**, and Z. Ao. “Active electro-physiological system for determining function of biological neuronal networks.” U.S. Patent App. PCT/US2024/040483.
- F. Guo, **H. Cai**, and Z. Ao. “A method for rapid generation of 3D organotypic cell clusters.” U.S. Patent App. 18/835,051.
- F. Guo, **H. Cai**, and Z. Ao. “Device and methods for engineering and measuring flattened 3D cell cultures.” U.S. Patent App. 18/861,349.
- F. Guo, Z. Ao, and **H. Cai**. “A device having a support structure for creating a hollow, three-dimensional organoids and cultures.” U.S. Patent App. 18/272,455.

Selected Awards and Honors

- 2026:** University Distinguished Ph.D. Dissertation Award, Indiana University Bloomington.
- 2018:** People Scholarship – Special Award, Nanjing University.
- 2015:** Third Elite Program Scholarship, Nanjing University.

Professional Service

- Journal reviewer for *Advanced Materials*, *Biofabrication*, *Bioactive Materials*, *Journal of Bionanotechnology*, *NPJ Biosensors*, *Scientific Reports*, *ACS Biomaterials Science & Engineering*, *Analytica Chimica Acta*, *The Journal of the Acoustical Society of America*, and *Physics in Medicine and Biology*.

References

References available upon request.