

## Minghui (Scott) Zhao

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<https://scholar.google.com/citations?user=Uy96fo8AAAAJ>

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### Education

#### Columbia University

Ph.D. in Electrical Engineering (Advisor: Prof. Xiaofan (Fred) Jiang)

M.S. in Computer Engineering

*Presidential Fellowship, Jacob Millman Award*

*New York, NY, USA*

09/2022 – Present

01/2021 – 05/2022

#### University of California – San Diego

B.S. in Electrical Engineering

*University Honors, Henry G. Booker Memorial Honors, Best Tutor Award*

*La Jolla, CA, USA*

08/2016 – 12/2020

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### Research Interest

My research focuses on **Embodied and Embedded AI Systems** that make artificial intelligence accessible, modular, and seamlessly integrated into everyday life. I build complete end-to-end systems spanning three layers: intelligent cores with physical capabilities (agentic AI and autonomous platforms), powerful backends (novel sensing techniques and control algorithms), and accessible frontends (modular hardware platforms, natural language interfaces, and voice-based interactions). These systems enable AI to perceive, understand, and interact with real-world across applications in **smart homes, health monitoring, wearable computing, and autonomous systems**, creating a future where intelligent technology is an active, adaptable participant in our daily lives.

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### Awards

- 2025 Columbia University Jacob Millman Award (For Outstanding Teaching Assistants)
- Best Paper: ACM HumanSys 2025
- Second Place Winner. Student Research Competition at ACM MobiCom 2024
- Best Demo Runner-Up: ACM MobiCom 2024
- Lightning Talk Award: SRC CogniSense Annual Review 2024
- Best Demo Award: SRC CogniSense Annual Review 2023
- Best Demo Award: ACM/IEEE IPSN 2023
- Best Demo Runner-Up: ACM SenSys 2022
- 2022 Columbia University Presidential Fellowship
- 2020-2021 Henry G. Booker Memorial Honors Award
- 2020 ECE Best Tutor Award
- First Award. SD Hacks 2019: Best Use of AWS AI/ML Services
- Honorable Mention. LA Hacks 2019: Site 1001 Big Data Award

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### Selected Publications

*Note: In mobile computing area, top conferences are considered premier venue of publication.*

*UbiComp / IMWUT, SenSys, MobiCom are flagship conferences listed at CSRankings.*

- **Zhao, M.**, Xia, J., Hou, K., Liu, Y., Xia, S., & Jiang, X. (2025, May). Flexifly: Interfacing the physical world with foundation models empowered by reconfigurable drone systems. In *Proceedings of the 23rd ACM Conference on Embedded Networked Sensor Systems (SenSys'25)*. <https://doi.org/10.1145/3715014.3722081> (Acceptance rate:  $46/244 = 19\%$ )
- **Zhao, M.**, Hou, K., Xia, J., Liu, Y., Xia, S., & Jiang, X. (2025, October). EmbodiedFly: Embodied LLM Agent with an Autonomous Reconfigurable Drone. In *Proc. of ACM Trans. Internet Things (TIIoT'25)*. <https://doi.org/10.1145/3772079>
- **Zhao, M.**, Sui, Y., Xia, J., Jiang, X., & Xia, S. (2024, May). TRAMBA: A Hybrid Transformer and Mamba Architecture for Practical Audio and Bone Conduction Speech Super Resolution and Enhancement on Mobile and Wearable Platforms. In *Proceedings of the ACM on Interactive, Mobile, Wearable, and Ubiquitous Technologies*. 8, 4, Article 205 November 2024 (*UbiComp'24 / IMWUT*). <https://doi.org/10.1145/3699757>

- **Zhao, M.**, Xia, S., Adhivarahan, C., Hou K., Chen, Y., Nie J., Wu E., Dantu K., & Jiang X. (2023, October). Anemoi: A Low-cost Sensorless Indoor Drone System for Autonomous Mapping of 3D Airflow Fields. In *Proceedings of the 29th Annual International Conference on Mobile Computing And Networking (MobiCom'23)*. ACM. <https://doi.org/10.1145/3570361.3613292> (Acceptance rate: 92/377 = 24%)
- **Zhao, M.**, Xia, S., Nie, J., Hou, K., Dhupar A., & Jiang, X. (2023, May). LegoSENSE: An Open and Modular Sensing Platform for Rapidly-Deployable IoT Applications. In *2023 IEEE/ACM Eighth International Conference on Internet-of-Things Design and Implementation (IoTDI'23)*. IEEE. <https://doi.org/10.1145/3576842.3582369> (Acceptance rate: 33/109 = 30%)
- **Zhao, M.**, Chang, T., Arun, A., Ayyalasomayajula, R., Zhang, C., & Bharadia, D. (2021, September). ULoc: Low-Power, Scalable and cm-Accurate UWB-Tag Localization and Tracking for Indoor Applications. In *Proceedings of the ACM on Interactive, Mobile, Wearable, and Ubiquitous Technologies*. 5, 3, Article 140 September 2021 (*UbiComp'21 / IMWUT*). <https://doi.org/10.1145/3478124>
- Nie, J., Fan, Y., Xuan, Z., **Zhao, M.**, Wan, R., Preindl, M., & Jiang, X. (2025, June). SoundTrack: A Contactless Mobile Solution for Real-time Running Metric Estimation for Treadmill Running in the Wild. In *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*. 9, 2, Article 42 June 2025. (*UbiComp'25 / IMWUT*) <https://doi.org/10.1145/3729486>
- Nie, J., Fan, Y., **Zhao, M.**, Wan, R., Xuan, Z., Preindl, M., & Jiang, X. (2025, May). Multi-modal dataset across exertion levels: Capturing post-exercise speech, breathing, and phonocardiogram. In *Proceedings of the 23rd ACM Conference on Embedded Networked Sensor Systems (SenSys'25)*. <https://doi.org/10.1145/3715014.3722065> (Acceptance rate: 46/244 = 19%)
- Nie, J., Xia, S., Liu, Y., Ding, S., Hu, L., **Zhao, M.**, ... & Jiang, X. (2023, June). A data-driven and human-centric ev charging recommendation system at city-scale. In *Proceedings of the 14th ACM International Conference on Future Energy Systems (e-Energy'23)*. <https://doi.org/10.1145/3575813.3597350> (Acceptance rate: 160/446 = 36%)

#### Workshop Publications

- Sui, Y., Zhang, Y., Liu, Y., **Zhao, M.**, Hou, K., Nie, J., ... & Xia, S. (2025, May). DomAIIn: Towards Programless Smart Homes. In *Proceedings of the 3rd International Workshop on Human-Centered Sensing, Modeling, and Intelligent Systems (HumanSys'25)*. **Best Paper Award**. <https://doi.org/10.1145/3722570.3726888>
- Sui, Y., **Zhao, M.**, Xia, J., Zhang, Y., Jiang, X., & Xia, S. (2025, May). DUal-NET: A Transformer-Based U-Net Model for Denoising Bone Conduction Speech. In *Proceedings of the 3rd International Workshop on Human-Centered Sensing, Modeling, and Intelligent Systems (HumanSys'25)*. <https://doi.org/10.1145/3722570.3726887>
- Xuan, Z., Liu, M., Nie, J., **Zhao, M.**, Xia, S., & Jiang, X. (2023). CaNRun: Non-Contact, Acoustic-based Cadence Estimation on Treadmills using Smartphones. In *Proceedings of Cyber-Physical Systems and Internet of Things Week 2023 (IASA'23)*. <https://doi.org/10.1145/3576914.3589561>
- Nie, J., Shao, H., **Zhao, M.**, Xia, S., Preindl, M., & Jiang, X. (2022, July). Conversational ai therapist for daily function screening in home environments. In *Proceedings of the 1st ACM International Workshop on Intelligent Acoustic Systems and Applications (IASA'22)*. <https://doi.org/10.1145/3539490.3539603>
- Morris, K., **Zhao, M.**, Lam, J., Jacobsen, G., Horgan, S., & Talke, F. E. (2019, June). A Wearable Neck Measurement Device and Monitoring System to Improve Ergonomic Performance of Surgeons. In *Information Storage and Processing Systems (ISPS'19)*. American Society of Mechanical Engineers. <https://doi.org/10.1115/ISPS2019-7513>

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#### Professional Experience

<b>Microsoft Research</b> Ph.D. Research Intern	Redmond, WA, USA Summer 2025
<b>Northwestern University – Department of Electrical and Computer Engineering</b> Visiting Scholar	Evanston, IL, USA Jan 2024 – Jun 2024
<b>Tencent Pixel Lab</b> Ph.D. Research Intern	New York, NY, USA Summer 2023

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#### Invited Talks

- **Microsoft Research** Redmond, WA, USA  
Interfacing the Physical World with Foundation Models Empowered by Reconfigurable Drone Systems 07/2025

- **UC San Diego**  
Lecture: Printed Circuit Board – From Idea to Mass Production

La Jolla, CA, USA  
09/2020

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## Professional Service

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### Organizing Committee

- Web Chair, ACM SenSys 2025
- Web Chair, ACM/IEEE IPSN 2023

### Reviewer

- ACM IMWUT 2023, 2024, 2025
- IEEE Transactions on Mobile Computing (TMC) 2025
- ACM Transactions on Sensor Networks (TOSN) 2024, 2025
- Smart Health 2025
- Engineering Applications of Artificial Intelligence (EAAI) 2025
- ACM MobiSys Artifact Evaluation 2023

### Services

- Columbia EE Department Student Ambassador 2023

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## Teaching and Outreach

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### Columbia University

Course / Teaching Assistant

2025 *Jacob Millman Award* (for outstanding teaching assistants)

- EECS E4764: AIoT – Artificial Intelligence of Things – Intelligent and Connected Systems      Fall 2021, Fall 2023
- EECS E6908: Embedded AI      Spring 2023

### UC San Diego

Tutor / Undergraduate Teaching Assistant

2020 *ECE Best Tutor Award*

- ECE5: Intro to ECE (Lab & Hands-on Projects)      Fall {2016, 2017, 2018, 2019, 2020}, Winter {2018, 2019, 2020}  
Spring {2018, 2019, 2020}, Summer {2017, 2018}
- ECE16: Rapid Hardware & Software Design for Interfacing with the World      Spring 2017

### Outreach

- **Girls Science Day – Women in Science at Columbia**      2022, 2023  
Hosted workshops in two years for female middle school students, teaching concepts in wireless embedded systems and sensors, and how to build sensing and artificial intelligence systems to improve our physical and daily lives.
- **Triton Summer STEM Academy – High School Students in STEM**      2017, 2018  
Hosted hands-on workshops in two years for high school students interested in STEM, guiding them building a robotic finger. The curriculum covered Arduino embedded programming with sensors and actuators, basic electrical circuits, and the assembly of 3D-printed mechanical linkages to provide an introduction to engineering.
- **UCSD Triton Day, ECE Day, Homecoming – Future College Students**      2017, 2018, 2019  
Represented the ECE department at 7+ large-scale outreach events for UCSD, engineering school, and organizations including the Society of Women Engineers. Engaged prospective middle and high school students by demonstrating hands-on projects from the introductory ECE curriculum, including Arduino programming, circuits, custom-built audio amplifiers, PCBs, and line-following robots.
- **Santa Barbara Impact Hub Open House – Makers and Educators in the area**      2017  
Presented UCSD's innovative hands-on engineering curriculum at a showcase for the Santa Barbara maker and educator community. Exhibited a range of projects, from embedded systems to custom-built robots.

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## Experience

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Columbia University Intelligent and Connected Systems Lab  
Research Assistant (advisor: Prof. Xiaofan (Fred) Jiang)

New York, NY, USA  
Sep 2021 – Present

- **Embodied LLM Agent with an Autonomous Reconfigurable Drone (FlexiFly)**: Developed a complete system integrating 1) an LLM agent that processes natural language commands and environmental context to make decisions, and 2) a reconfigurable drone platform that executes these decisions by selecting appropriate payloads and performing physical tasks base on the agent's instructions. Created a foundation model orchestration framework using LangGraph by integrating multiple LLMs with vision models for real-time environmental understanding, task interpretation, and sensor data analysis. Designed an efficient payload switching mechanism using a repurposed 3D printer, modular container system, and self-aligning robotic claws, enabling rapid payload swaps in under 20 seconds. Designed and conducted comprehensive user studies in real smart home environments and demonstrated an 85% improvement in diverse task completion rates, addressing key challenges in deploying foundation models for physical world interaction. (**first author paper** at ACM SenSys'25, **first author paper** to appear at ACM TIoT'25, **best demo runner-up** at ACM MobiCom'24, **second place winner** at ACM MobiCom'24 Student Research Competition)
- **Sensor-less Autonomous 3D Airflow Mapping Using Palm-sized Off-the-Shelf Drones (Anemol)**: Developed algorithms to enable a low-cost off-the-shelf palm-sized microdrone, to autonomously measure 3D airflow fields in indoor environments leveraging only motor control signals, without hardware modifications, onboard or external sensors. Performed drone STM32 C firmware modifications to extract and stream motor control data. Created algorithms and benchmarking systems to collect motor control data, predict airflow, and control the drone. (**first author paper** at ACM MobiCom '23, **demo** at ACM MobiSys '22).
- **Accessible IoT and Programless Smart Home Systems**: Architected and developed end-to-end systems to dramatically lower the barrier for smart home and IoT adoption, from physical deployment to logical automation. Created *LegoSENSE*, a zero-code, plug-and-play modular sensing platform with 9 custom-designed PCBs (KiCad) with 16 sensors, and full-stack middleware (C, Python) for hassle-free data acquisition. Developed *DomAIn*, a smart home platform that automatically generates and deploys complex task logic from natural language, eliminating the need for manual user programming. Validated through real-world deployments and user studies, demonstrating increased productivity and improving key usability factors by up to 38% over existing solutions. Used the platform in two STEM outreach events with middle school and high school students (**first author publication** at ACM/IEEE IoTDI '23, **best paper** at ACM HumanSys'25, **demo** at ACM MobiSys '22).
- **Acoustic-based Mobile Health Systems for Running Analytics**: Developed a suite of non-contact mobile solutions (*CaNRun*, *SoundTrack*) that leverage on-device machine learning (LSTM, MLP) to estimate real-time running metrics (cadence, ground contact time) and post-exercise exertion levels solely from acoustic data captured by a smartphone. Created and curated two comprehensive datasets from over 60 subjects in diverse, real-world environments, including a 40-hour collection of treadmill running sounds from 13 public gyms, and a multi-modal dataset of post-exercise speech, breathing, and heart sounds. Achieved performance superior or comparable to commercial wearables (e.g., Apple Watch). (**publications** at ACM SenSys'25, ACM IMWUT'25, ACM IASA'23)
- **Low-Cost Long-Range Precise Drone Landing System using Infrared (AIRA)**: Developed a novel, cost-effective infrared-based platform for precise landing of resource-constrained microdrones. Designed a system using an off-the-shelf infrared light bulb at the landing station and an energy and compute-efficient photodiode (PD) sensing platform on the drone. Implemented and evaluated the platform on both a custom-designed palm-sized microdrone with PX4 and a retrofitted off-the-shelf DJI drone. Created a two-stage algorithm enabling navigation from up to 11 meters with path obstructions and precise landing within 10cm error. Achieved 9.2x range improvement over existing vision-based methods while maintaining low cost and compute requirements, as well as robustness in low-light and non-line-of-sight conditions. (**first author paper** under submission)
- **Automated Daily Activities Screening using Smart Home Infrastructure**: Built a system that interfaces with existing low-cost smart home sensors to predict and classify human activities. Developed hardware and C firmware code to interface with 7 different types of sensors acting as wireless nodes streaming data to activity prediction models; developed algorithms for detecting daily activities (e.g., showering, cooking, sleeping) and achieved 88% accuracy. Developed mobile app using Flutter for data collection and labeling. Deployed and conducted user studies in 5 subject homes throughout a 14-day period (**best demo runner-up** at ACM SenSys '22, **paper** at ACM IASA '22).
- **High-Speed Optical Communication using Diffused Infrared Laser**: Built a wireless transmitter and receiver system using an infrared laser, diffuser, collimator, and avalanche photodiode to perform optical communication at 100 MHz, leveraging ambient diffused reflections from the laser. Analyzed the receiver signal and developed data processing

code in SystemVerilog, C, and Python. Designed hardware to power and interface the components (**best demo** at ACM/IEEE IPSN'23).

## Microsoft Research

Redmond, WA, USA

### Ph.D. Research Intern

Jun 2025 – Aug 2025

- **Wearable Voice Interface for Agentic LLM**: Designed, prototyped, and evaluated a voice-controlled wearable ring, enabling users to seamlessly issue complex tasks to agentic LLMs on the go for background execution. Developed the end-to-end system architecture, including the mobile application and BLE firmware, to establish stable connectivity between the ring, a smartphone, and the agentic frameworks. Implemented a functional prototype by integrating the wearable with agentic backends including VS Code Copilot and two other internal agentic frameworks, and developed an additional LLM agent orchestration layer using LangGraph to improve task success rates in minimal-feedback scenarios. Led the full user study lifecycle, which resulted in an iterative refinement of the interaction model and the addition of an audio feedback mechanism. Collaborated with multiple cross-functional teams, including HCI experts to refine the user experience, internal AI agent teams to integrate their frameworks, and an audio privacy research team to implement user-specific voice authentication. Presented the final system in demos to company leadership, media teams, and internal workshops, showcasing a tangible vision for future agent-enabled wearables.

## Northwestern University Intelligent Mobile and Embedded Computing Lab

Evanston, IL, USA

### Visiting Scholar (advisor: Prof. Stephen Xia)

Jan 2024 – Jun 2024

- **Wearable Low-power Speech Enhancement Platform (TRAMBA)**: Improved wearable wireless microphone technology by developing a novel speech enhancement platform for bone-conduction microphones and accelerometer. Designed and implemented a data collection system capturing audio from multiple sensor types across various facial locations. Implemented a low-power wearable system using nRF52840-based platform with Bluetooth Low Energy (BLE) for efficient data transmission. Packaged the system in a 3D printed smart glass form-factor, and conducted user study across 10 subjects. Optimized data transmission to achieve up to 160% improvement in wearable battery life through BLE parameter optimization and sampling rate reduction, while maintaining speech quality using a hybrid transformer and Mamba architecture. Demonstrated significant word error rate improvements (up to 75%) in noisy environments compared to traditional over-the-air speech enhancement methods. (**first author paper** in ACM IMWUT'24, **publication** in HumanSys'25, **poster** at ACM Mobicom'24)

## Tencent Pixel Lab

New York, NY, USA

### Ph.D. Research Intern

Jun 2023 – Sep 2023

- Proposed and built a light stage with 800+ addressable and wirelessly controlled high-power light-emitting diodes (LEDs) with polarizers to provide fine-grained structural lights to relight objects for 3D reconstruction. Designed modular PCBs for LED lights, the power system, and wireless controllers. Developed C firmware with ESP32 to support scalable wireless brightness adjustments for each of the 800 LEDs with millisecond-level latency.
- Built automation software in Python and C++ to interface light systems with industrial cameras; built hardware systems to synchronize industrial cameras with video frames.

## UC San Diego Wireless Communications Sensing and Networking Lab

La Jolla, CA, USA

### Research Assistant (advisor: Prof. Dinesh Bharadia)

Apr 2019 – Oct 2021

- **Centimeter-accurate Scalable 3D UWB Tag Localization**: Designed an indoor 3D positioning system employing an array of ultra-wideband (UWB) radio frequency (RF) transceivers and achieved state-of-art accuracy, latency, scalability, and power consumption. Developed embedded firmware and hardware systems for the UWB transceivers and the PCBs for an eight-transceiver array. Processed the RF signal data and analyzed the performance and limits of the system. Evaluated and optimized various methods and algorithms in angle of arrival estimation and location solving to reduce the median 3-D localization error to 3.6 cm (**first author paper** in IMWUT / UbiComp '21).

## UC San Diego Talke Lab

La Jolla, CA, USA

### Research Assistant (advisor: Prof. Frank E. Talke)

Apr 2017 – Jun 2019

- **Wireless Wearables for Ergonomic Motion Tracking**: Developed an embedded, wireless hand and ergonomic self-contained motion tracking system to improve the surgical operation training and ergonomic health monitoring of medical students and doctors. Designed 3 PCBs and 3D printed enclosures for sensor and microcontroller boards; assembled a working demo, and successfully performed trials in hospitals (**publication** in ISPS '19).