KAIYUAN HOU

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Research Interests: Smart Health • Human-Computer Interaction • Deep Learning • LLM

RESEARCH INTEREST

My research lies at the intersection of embedded AI, machine learning, data analytics, and their applications in smart health. I am passionate about solving impactful real-world problems that make a difference in people's lives. My current projects focus on leveraging foundational models to create intelligent and generalized systems for home assistance and human health monitoring, as well as improving large language models (LLMs) in understanding the physical world. Additionally, I am working on AR/VR technologies to help people visualize invisible objects, phenomena, or data, thereby adding a new dimension to human-computer interaction and data interpretation.

EDUCATION

Columbia University New York, NY, USA
Ph.D. Electrial Engineering **4.03/4.00** **09/2021 - Expected 2027**
Research Advisor: Dr. Xiaofan (Fred) Jiang
Course: , Generative AI, Computer Network, Cloud Computing, Big Data, Reinforcement Learning, Embedded AI, Blockchain, Database, Random Signals, Deep Learning, Digital Signal Processing, Sparse Model, SaaS, Mobile Computing

University of Colorado Boulder Boulder, CO, USA
B.S. Electrical Engineering **3.98/4.00** **09/2017 - 05/2021**
Summa Cum Laude; Member of Tau Beta Pi; Dean's list from 2017 fall to 2021 fall; Merit Scholarship
Course: Computer Architecture, Control Theory, Microelectronics, Linear Systems, Embedded System, Algorithm, Data Structure, Complex Variables, Ordinary Differential Equations, Probability, Quantum Computing, Quantum Physics

RESEARCH EXPERIENCE

Intelligent and Connected Systems Lab, Columbia University **09/2021 - Present**
Graduate Research Assistant
Continuous multi-person fever screening system: Developed a low-cost RGB-thermal camera system for continuous multi-person fever screening. Implemented real-time algorithms for tracking and reconstructing personalized 3D head model for each head detected. The system achieved a measurement error rate of within 0.4°F at 2 meters and 0.6°F at 3.5 meters across diverse demographics without introducing bias on different skin colors. Deployed multiple systems at a clinic, a medical school, and a restaurant for a total of about three years, successfully screening over 40,000 individuals and detecting more than 3,000 fever cases. (IPSN 2022)
Modular sensing platform: Developed a plug-and-play platform based on Raspberry Pi, designed for no-code data acquisition, enabling users to easily mix and match various sensors. Contributed to system architecture design and conducted evaluations focused on ease of use, flexibility, and scalability. (Mobisys 2022, IoTDI 2023)
AR assisted intelligent stethoscope platform: Created an Augmented Reality (AR)-assisted stethoscope platform to guide users in performing auscultation at home. The system leverages pose estimation, computer graphics, acoustic intelligence, human-computer interaction, and signal processing algorithms, enabling non-expert users to perform 4-point auscultation screening in approximately 13 seconds per point. This approach achieved a 46.57% improvement in accuracy for auscultation point positioning compared to baseline methods. Comprehensive evaluations confirmed the effectiveness of AR guidance in enhancing user performance. (Sensys 2022, IPSN 2023)
Airflow measurement with UAV: Developed a low-cost drone system for 3D airflow mapping in indoor environments. The motor controllers adaptively adjust their behavior to compensate for wind-induced turbulence, which makes the drone an effective tool for airflow measurement. Implemented various drone firmware with multiple control schemes to explore their impact on measurement accuracy. The system achieved wind speed and direction measurements with errors up to 0.41 m/s and 25.1°, outperforming the existing state of the art, and mapped 3D airflow fields with an average RMS error of 0.73 m/s. (MobiCom 2023)
Reconfigurable Drone as an Automated Smart Home Assistant: Developed a lightweight indoor drone capable of acting as an autonomous smart home assistant for tasks such as item localization, monitoring, and delivery. By incorporating various foundation models, the drone autonomously understands its environment and user commands. Designed a

modular swapping mechanism—both mechanical and electrical—that enables the drone to load or unload sensing or actuating modules from a landing platform equipped with a crawler belt panel holding different modules. Leveraged LangGraph to implement a large language model (LLM) agent for task comprehension and scene understanding using bird's-eye view images. Upon landing, the agent determines which module to load based on the user's command and directs the drone accordingly. Additionally, implemented an image cropping algorithm to enhance visual language model (VLM) performance, allowing it to detect small objects within the scene more effectively. (Under review)

AIoT Lab, The Chinese University of Hong Kong **01/2024 - 06/2024**
Visiting Student & Research Assistant
AR-Enhanced Sensor Representation: Transformed sensor data from smart buildings into intuitive, immersive 3D visualizations using Augmented Reality (AR) and 3D Gaussian Splatting (3DGS). Developed an embedding blending approach to address biases in the embedding space, where the similarity between embeddings of different values does not always align with their actual differences, impacting visualization quality. This method uses anchor-based estimations, blending pre-computed embeddings of anchor points after profiling the embedding space, rather than directly computing the embedding for each input. This approach ensures continuous and smooth visualization transitions, maintaining stability even under changing conditions, by ensuring the visualization accurately reflects changes in sensor inputs without abrupt or inconsistent transitions. (Under review)

LASP, University of Colorado Boulder **09/2020 - 05/2021**
Undergraduate Research Assistant
· *The Medium Energy Electron Telescope (MEET)*: A 1U CubeSat-compatible instrument to study the source, loss, intensity, and dynamic variation of 30-400 keV electrons in Earth's inner belt. Implement a detector simulator circuit that met stringent performance metrics, including an energy resolution of less than 500 eV, a charge collection time of 200 ns, and a maximum count rate exceeding 500 kHz. Design the simulator's PCB board, and also contribute to the design of the charge-sensitive amplifier (CSA). The project's performance was validated through ground-based simulations using FPGA on CmodA7.

AWARDS

· Third Place - ECE Capstone Project 2021, University of Colorado Boulder
· Best ECE Undergraduate Freshman Project 2017, University of Colorado Boulder

NEWS AND MEDIA

EurekAlert! 2022 - Cheaper, faster, safer way to screen temperatures

PROFESSIONAL SERVICE

Volunteer: CPS-IoT Week 2024, SIGCOMM 2023

Proxy Presenter: ACM/IEEE IPSN 2023

Web Chair: ACM Mobisys 2022 Workshop IASA

TEACHING AND OUTREACH

Columbia University **09/2021 - 12/2023**
Teaching Assistant
EECS E4764 Internet of Things - Intelligent and Connected Systems: Mentored students with hands-on projects on smart watch and various personal course projects, prepared lab section presentations, developed and graded the exam.
EECS E6892 Reinforcement Learning in Information Systems: Prepared homework starting code, helped students on course projects' proposal and implementations, graded homework and projects.
ELEN E6883 An Introduction to Blockchain Technology(two semesters): Help students on course projects on building personal smart contracts, graded homework and exam.

University of Colorado Boulder **09/2019 - 05/2021**
Course Assistant

ECEN 2260 Circuits as Systems(two semesters): Prepared 2-hour long review sessions before every exam, gave lectures when instructor is not available, graded homework and exams.
ECEN/CSCI 4593 Computer Organization(two semesters): Helped students implement a 5-stage pipeline RISC-V processor and optimizations (bypassing and memory hierarchy). Graded homework and exams, answered students questions during class.

Outreach and Other Activities

· High School Science and Innovation Seminar, Alma Mater 2024
Delivered a presentation on the background and applications of sensing technology in smart health, autonomous driving, and unmanned aerial vehicles (UAVs), as well as current research trends in these areas.

· Society of Women Engineers Workshop 2023
Assisted in hosting a workshop focused on teaching female high school students about sensor networks, encouraging their interest and participation in STEM fields.

· Mentors for Undergraduate Researches
Columbia University Undergraduate Research Symposium 2023
- *Thilina Balasooriya* on studying the effect of skin color for temperature estimation with thermal cameras. *Summer Undergraduate Research Experience (SURE) Program* 2022
- *Alfonso Rivas* on the development of a scalable, low-cost fever screening system.
- *Nia Cole* on creating a digital stethoscope for diagnoses with augmented reality (Best Presentation Award).

PUBLICATIONS

Y Liu, M Zhao, **K Hou**, J Xia, C Carver, S Xia, X Zhou, X Jiang, (2024) **AIRA: A Low-cost IR-based Approach Towards Autonomous Precision Drone Landing and NLOS Indoor Navigation**, *arXiv preprint arXiv:2407.05619*

Y. Guo, **K. Hou**, Z.Yan, H. Chen, G. Xing, and X. Jiang, (2024). **Sensor2Scene: Foundation Model-driven Interactive Realities**, *International Workshop on Foundation Models for Cyber-Physical Systems & Internet of Things (FMSys) 2024* pp. 13-19

M. Zhao, J. Xia, **K. Hou**, Y. Liu, S. Xia, X. Jiang, (2024). **RASP: A Drone-based Reconfigurable Actuation and Sensing Platform Towards Ambient Intelligent Systems**, *arXiv preprint arXiv:2403.12853*

S. Xia, M. Zhao, C. Adhivarahan, **K. Hou**, Y. Chen, J. Nie, E. Wu, K. Dantu, X. Jiang, (2023).**Anemoi: A Low-cost Sensorless Indoor Drone System for Automatic Mapping of 3D Airflow Fields**, *The 29th Annual International Conference On Mobile Computing And Networking (MobiCom) 2023* pp. 1-16.

K. Hou, S. Xia, E. Bejerano, J. Wu & X. Jiang, (2023). **ARSteth: Enabling Home Self-Screening with AR-Assisted Intelligent Stethoscopes**, *The 22nd ACM/IEEE Conference on Information Processing in Sensor Networks (IPSN) 2023* pp. 205-218.

M. Zhao, S. Xia, J. Nie, **K. Hou**, A. Dhupar & X. Jiang, (2023). **LegoSENSE: An Open and Modular Sensing Platform for Rapidly-Deployable IoT Applications**, *8th ACM/IEEE Conference on Internet of Things Design and Implementation (IoTDI) 2023* pp. 367-380.

K. Hou, S. Xia, J. Wu, M. Zhao, E. Bejerano, X. Jiang, (2022). **AI Stethoscope for Home Self-Diagnosis with AR Guidance**, *The 20th ACM Conference on Embedded Networked Sensor Systems (Sensys) 2022*

K. Hou, S. Xia, & X. Jiang, (2022). **BuMA: Non-Intrusive Breathing Detection using Microphone Array**, *ACM International Workshop on Intelligent Acoustic Systems and Applications (IASA) 2022* pp. 1–6.

M. Zhao, Y. Liu, A. Dhupar, **K. Hou**, S. Xia, X. Jiang, (2022). **A modular and reconfigurable sensing and actuation platform for smarter environments and drones: demo abstract**, *20th Annual International Conference on Mobile Systems, Applications and Services (Mobisys) 2022.*

K. Hou, Y. Liu, P. Wei, C. Yang, H. Kang, S. Xia, T. Spada, A. Rundle, & X. Jiang, (2022).**A Low-Cost In- situ System for Continuous Multi-Person Fever Screening**, *Information Processing in Sensor Networks (IPSN) 2022* pp. 15-27.