

Xiaomin Ouyang

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Electrical and Computer Engineering Department

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RESEARCH INTEREST

My main research interest is building **AI-powered IoT and mobile systems**, with a primary focus on developing **efficient machine learning and sensing systems for smart health applications**.

- **Machine Learning Systems for IoT**: addresses real-world challenges for advancing ML in mobile/IoT systems, such as distributed and imperfect IoT data, scalability, limited resources, and real-world system dynamics.
- **Smart Health**: design and deploy real-world IoT systems for personalized health monitoring and intervention, e.g., developing multi-modal federated learning systems for monitoring digital biomarkers of Alzheimer's Disease.
- **Mobile Sensing**: enhance sensing quality with physics-strengthened AI techniques, e.g., exposing texture information from ToF cameras for sensing in the dark.

Key words of my recent research: multi-modal sensing and learning, federated learning systems, large language models, activity recognition, digital biomarkers, ToF depth sensing.

PROFESSIONAL EXPERIENCE

Incoming Assistant Professor

Department of Computer Science and Engineering, HKUST

Starting from Aug. 2024

Clear Water Bay, Kowloon, Hong Kong

Postdoctoral Researcher

ECE Department, University of California, Los Angeles

Advisor: Prof. Mani Srivastava

Oct. 2023 – Present

Los Angeles, CA, U.S.

EDUCATION

Ph.D., Information Engineering

The Chinese University of Hong Kong

Advisor: Prof. Guoliang Xing, Co-Advisor: Prof. Jianwei Huang

Aug. 2019 – July 2023

Hong Kong

B.Eng., Communication and Information Engineering

Xiamen University (GPA Rank: 1/68)

Sep. 2015 – June 2019

Xiamen, China

SELECTED AWARDS AND HONORS

- **mHealth Scholars**, NIH mHealth Training Institute (mHTI), 2024
- **Rising Stars in EECS**, Georgia Institute of Technology, 2023
- **Outstanding Doctoral Dissertation Award**, ACM SIGBED China, 2023
- **Best Paper Award (1/198)**, ACM MobiSys, 2023
- **Best Presentation Award of Rising Stars Forum**, ACM MobiSys, 2023
- **N2Women Young Researcher Fellowship**, ACM MobiSys, 2023
- **Reaching Out Award**, The Chinese University of Hong Kong, 2023
- **Student Travel Grant**, ACM MobiSys 2023 & ACM MobiCom 2022
- **National Scholarship** (three times), Highest honor in China, 2018 & 2017 & 2016
- **The First Prize** (1.8% of 14406 teams), National Undergraduate Electronic Design Contest of China, 2017

Conference Papers

- FlexLoc: Conditional Neural Networks for Zero-Shot Sensor Perspective Invariance in Object Localization with Distributed Multimodal Sensors
Jason Wu*, Ziqi Wang*, Xiaomin Ouyang, Ho Lyun Jeong, Colin Samplawski, Lance Kaplan, Benjamin Marlin, Mani Srivastava
IEEE/RSJ IROS, 2024 (Acceptance Rate: 47.5%).
- ADMarker: A Multi-Modal Federated Learning System for Monitoring Digital Biomarkers of Alzheimer’s Disease
Xiaomin Ouyang, Xian Shuai, Yang Li, Li Pan, Xifan Zhang, Heming Fu, Sitong Chen, Xinyan Wang, Shihua Cao, Jiang Xin, Hazel Mok, Zhenyu Yan, Doris Yu, Timothy Kwok, Guoliang Xing
ACM MobiCom, 2024 (Winter Acceptance Rate: 23.1%).
- Mozart: A Mobile ToF System for Sensing in the Dark through Phase Manipulation
Zhiyuan Xie*, Xiaomin Ouyang* (*co-first authors), Li Pan, Wenrui Lu, Guoliang Xing, Xiaoming Liu
ACM MobiSys, 2023 (Acceptance Rate: 20.7%). **Best Paper Award (1 out of 198 submissions)**
- Harmony: Heterogeneous Multi-Modal Federated Learning through Disentangled Model Training
Xiaomin Ouyang, Zhiyuan Xie, Heming Fu, Sitong Chen, Li Pan, Guoliang Xing, Jiayu Zhou, Jianwei Huang
ACM MobiSys, 2023 (Acceptance Rate: 20.7%).
- Cosmo: Contrastive Fusion Learning with Small Data for Multimodal Human Activity Recognition
Xiaomin Ouyang, Xian Shuai, Jiayu Zhou, Ivy Wang Shi, Zhiyuan Xie, Guoliang Xing, Jianwei Huang
ACM MobiCom, 2022 (Acceptance Rate: 17.8%).
- ClusterFL: A Similarity-Aware Federated Learning System for Human Activity Recognition
Xiaomin Ouyang, Zhiyuan Xie, Jiayu Zhou, Jianwei Huang, Guoliang Xing
ACM MobiSys, 2021 (Acceptance Rate: 21.6%).
- FedDL: Federated Learning via Dynamic Layer Sharing for Human Activity Recognition
Linlin Tu, Xiaomin Ouyang, Jiayu Zhou, Yuze He, Guoliang Xing
ACM SenSys, 2021 (Acceptance Rate: 17.9%).
- UltraDepth: Exposing High-resolution Texture from Depth Cameras
Zhiyuan Xie, Xiaomin Ouyang, Xiaoming Liu, Guoliang Xing
ACM SenSys, 2021 (Acceptance Rate: 17.9%).

Journal Papers

- ClusterFL: A Clustering-based Federated Learning System for Human Activity Recognition
Xiaomin Ouyang, Zhiyuan Xie, Jiayu Zhou, Jianwei Huang, Guoliang Xing
ACM Transactions on Sensor Network, 19(1), 1-32, 2022.
- Optimization Design for Federated Learning in Heterogeneous 6G Networks
Bing Luo, Xiaomin Ouyang, Peng Sun, Pengchao Han, Ningning Ding, Jianwei Huang
IEEE Network, 37(2), 38-43, 2023.

Workshop and Demo Papers

- LLMsense: Harnessing LLMs for High-level Reasoning Over Spatiotemporal Sensor Traces
Xiaomin Ouyang, Mani Srivastava
SenSys-ML Workshop 2024, co-located with CPS-IoT Week 2024.
- Design and Deployment of Multi-Modal Federated Learning Systems for Alzheimer’s Monitoring
Xiaomin Ouyang
ACM MobiSys 2023 Rising Stars Forum. Best Presentation Award
- HiToF: A ToF Camera System for Capturing High-Resolution Textures
Zhiyuan Xie, Xiaomin Ouyang, Li Pan, Wenrui Lu, Xiaoming Liu, Guoliang Xing
ACM MobiCom 2022 Demo.

Design and Deployment of a Multi-Modal Federated Learning System for Alzheimer’s Disease Monitoring.

Alzheimer’s Disease (AD) is a growing health challenge worldwide. Existing approaches for AD diagnosis are usually intrusive and cannot be conducted routinely. We propose ADMarker, the first end-to-end system that integrates multi-modal sensors and new federated learning algorithms for detecting multidimensional AD digital biomarkers in natural living environments. We develop a compact multi-modality hardware system that can function for up to months in home environments. On top of the hardware system, we design a multi-modal federated learning system that can accurately detect more than 20 digital biomarkers in a real-time and privacy-preserving manner, which collectively addresses several major real-world challenges such as limited data labels, data heterogeneity, and limited computing resources. Our system has been deployed in a four-week clinical trial involving 91 elderly participants (31 with AD, 30 with mild cognitive impairment, and 30 cognitively normal subjects). The results indicate that ADMarker can accurately detect a comprehensive set of digital biomarkers with up to 93% accuracy and identify AD with an average of 88.9% accuracy.

Multi-Modal Human Activity Recognition (HAR) with Small Data.

Multi-modal sensing systems are essential for capturing complex human activities such as conversation and family meals, which are important digital biomarkers for Alzheimer’s disease. However, such systems also bring several new challenges including limited labeled multi-modal data. We propose Cosmo, a new system for multi-modal HAR with only limited labels on the user side. Cosmo features a novel two-stage training strategy that leverages both unlabeled data on the cloud and limited labeled data on edge. By integrating novel fusion-based contrastive learning and quality-guided attention mechanisms, Cosmo can effectively extract both consistent and complementary information across different modalities for efficient fusion. Our evaluation on a cloud-edge testbed using three real-world multi-modal HAR datasets shows that Cosmo delivers significant improvement over state-of-the-art baselines in both recognition accuracy and convergence delay.

A Similarity-Aware Federated Learning System for Privacy-Preserving Activity Recognition.

Federated learning (FL) is a privacy-preserving distributed machine learning approach, which only requires the nodes to upload model weights to avoid exposing users’ raw data during the learning process. However, existing FL paradigms yield unsatisfactory performance for a wide class of HAR applications due to the data heterogeneity of different users. We find that, in spite of the heterogeneity, data distributions of different users’ activities may share significant spatial-temporal similarity. We propose ClusterFL, a similarity-aware FL system that automatically captures the intrinsic clustering relationship among the data of different users to optimize both the model accuracy and convergence performance. Extensive experiments on an NVIDIA edge testbed using four new HAR datasets show the effectiveness of our approach.

Exposing High-Resolution Texture from ToF Depth Cameras.

Time-of-flight (ToF) depth cameras have been increasingly adopted in various real-world applications, which capture the depth information of the scene. We propose the first system that can generate high-resolution and rich-in-texture maps from off-the-shelf ToF cameras. Through in-depth analysis of the physical reflection model, we design two major approaches to manipulate the phase components for exposing high-resolution textures, including a hardware-based approach by introducing a distorting IR source and a software-based approach through phase manipulation functions. Extensive experiments on off-the-shelf smartphone models and standalone ToF camera platforms show that the output maps of our system deliver significant improvement over existing sensing technologies for various applications.

TEACHING AND MENTORSHIP

Mentorship

- Oct. 2023 - present, Pengrui Quan/Gaofeng Dong/Pragya Sharma/Jason Wu, Ph.D. Students at UCLA (major research projects, with Prof. Mani Srivastava)
- Oct. 2023 - present, Yolanda Lau, Ph.D. Student at University College London (invited in the thesis committee)
- Aug. 2022 - present, Yang Li, Ph.D. Student at CUHK (major research project, with Prof. Guoliang Xing)
- Aug. 2022 - present, Zihan Li, Undergraduate Student at CUHK-SZ (a first-author paper under submission)
- Oct. 2022 - May. 2023, Shangcheng Jin, Visiting Undergraduate Student at CUHK (final year project)
- Oct. 2021 - May. 2022, Kaiwei Liu, Visiting Undergraduate Student at CUHK (final year project)
- June 2020 - Jan. 2021, Qidong Zhai and Nan Zhang, Master Students at CUHK (final year projects)
- Oct. 2019 - June. 2020, Hoiying Siu and Jiaying Cheng, Undergraduate Students at CUHK (final year projects)

Teaching

- Teaching Assistant, Computer Networks, CUHK, 2022 Spring/2021 Spring/2020 Spring/2019 Fall
- Laboratory Tutor, Electronic Circuit Design Laboratory, CUHK, 2021 Fall/2020 Fall

Organizing Committee Member

- TPC Chair of International Workshop on Foundation Models for Cyber-Physical Systems & Internet of Things (co-located with CPS-IoT Week 2024)
- Web Chair of ACM/IEEE IPSN 2024
- Organizer of N2Women (Networking Networking Women) Meeting at ACM MobiSys 2023

Program Committee Member

- ACM SenSys 2024
- IEEE ICDCS 2024
- ACM MobiCom 2024 Artifact Evaluation
- ACM MobiSys 2024 Artifact Evaluation
- ACM Ubicom/ISWC 2024 Notes and Briefs
- ACM/IEEE IoTDI Posters/Demos Program, 2023/2024
- ACM SenSys 2022 Shadow Program

Reviewer

- Conference: ACM IMWUT/UbiComp 2022/2023/2024, IEEE INFOCOM 2022, ACM KDD 2021
- Journal: IEEE Transactions on Mobile Computing (TMC), IEEE/ACM Transactions on Networking (ToN), ACM Transactions on Sensor Networks (TOSN), ACM Transactions on Computing for Healthcare, IEEE Internet of Things Journal (IoTJ), International Journal of Computer Vision (IJCV)

TALKS

The Hong Kong University of Science and Technology <i>Design and Deployment of AI-powered IoT Systems for Smart Health</i>	Mar. 2024
Arizona State University <i>Design and Deployment of AI-powered IoT Systems for Smart Health</i>	Feb. 2024
University of Edinburgh <i>Design and Deployment of AI-powered IoT Systems for Smart Health</i>	Feb. 2024
EECS Rising Stars Workshop, Georgia Institute of Technology <i>Design and Deployment of AI-powered Mobile Health Systems</i>	Nov. 2023
Annual Meeting of the mDOT Center, Harvard University <i>Personalized and Private Health Monitoring and Interventions with LLMs</i>	Oct. 2023
Rising Stars Forum of ACM MobiSys 2023, University of Helsinki <i>Design and Deployment of Multi-Modal Federated Learning Systems for Alzheimer's Disease Monitoring</i>	June 2023
ACM MobiSys 2023, University of Helsinki <i>Harmony: Heterogeneous Multi-Modal Federated Learning through Disentangled Model Training</i>	June 2023
ACM MobiCom 2022, Sydney, Australia <i>Cosmo: Contrastive Fusion Learning with Small Data for Multimodal Human Activity Recognition</i>	Oct. 2022
ACM MobiSys 2021, Virtual <i>ClusterFL: A Similarity-Aware Federated Learning System for Human Activity Recognition</i>	June 2021

REFERENCES

Mani Srivastava (Postdoc Advisor)
Professor and Vice Chair
Electrical and Computer Engineering Department
University of California, Los Angeles
Email: mbs@ucla.edu

Jianwei Huang (Ph.D. Co-Advisor)
Presidential Chair Professor and Associate Vice President
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The Chinese University of Hong Kong, Shenzhen
Email: jianwei Huang@cuhk.edu.cn

Xiaofan (Fred) Jiang (Expertise in Mobile Health and CPS/IoT)
Associate Professor
Department of Electrical Engineering and Computer Engineering
Columbia University
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Guoliang Xing (Ph.D. Advisor)
Professor
Department of Information Engineering
The Chinese University of Hong Kong
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Jiayu Zhou (Thesis Committee, Close Collaborator)
Associate Professor
Department of Computer Science and Engineering
Michigan State University
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