

HANG QIU

hangqiu.github.io
hangqiu@waymo.com

RESEARCH INTERESTS

Collaborative Autonomous Systems, Cyber-physical Systems, Systems for ML, Edge ML, 3D Sensing, Cooperative Perception, Mapping and Localization, Mobile Computing, Wireless Networking.

APPOINTMENTS

Waymo , Bellevue, WA, USA	2022~ pres.
Software Engineer, Perception	
Stanford University , Stanford, CA, USA	2021~ 2022
Postdoctoral Scholar, Department of Electrical Engineering	
Waymo , Mountain View, CA, USA	summer 2021
Intern, Perception	
Microsoft Research , Redmond, WA, USA	2017~ 2019
Research Intern, Contractor, Mobility and Networking Group	
IBM Research , Yorktown Heights, NY, USA	summer 2015
Research Intern, T.J. Watson Research Center	

EDUCATION

Ph.D. Electrical and Computer Engineering	2020
University of Southern California, Los Angeles, USA	
Dissertation: Networked Cooperative Perception: Towards Robust and Efficient Autonomous Driving	
M.S. Computer Science	2020
University of Southern California, Los Angeles, USA	
B.S. Electronic Engineering	2013
Shanghai Jiao Tong University, Shanghai, China	
Thesis: Distributed Channel-Assignment and Throughput Control in Multi-Radio Multi-Channel Wireless Network	

PROFESSIONAL EXPERIENCE

Waymo LLC. , Software Engineer	Bellevue, WA, 2022~pres.
• Work in perception and mapping (details confidential).	
Stanford University , Postdoctoral Scholar	Stanford, CA, 2021~pres.
• Designed edge ML monitoring and debugging system, ML-EXray , a programming framework for end-to-end ML deployment validation to enable verifiable ML on edge devices.	
• Collaborated with Google and Meta to uncover deployment issues in industry edge ML production pipelines.	
General Motors R&D , Collaborator	Warren, MI, 2013~pres.

- Designed Augmented Vehicular Reality ([AVR](#)), a collaborative sensing system which enabled live extended 3D vision beyond occlusion and range for better autonomous driving decisions. [Featured in [GetMobile Magazine](#)]
- Built a lightweight self-healing HDMap system, [Carmap](#), which enabled real-time 3D map difference updates, and invented a robust simultaneous localization and mapping (SLAM) approach leveraging map differences.
- Designed scalable cooperative perception system ([AutoCast](#)) that coordinates and schedules sensor sharing among clusters of vehicles, enabling live extended 3D vision for dense traffic scenarios.
- Invented cooperative autonomous driving model, [Coopernaut](#), which encodes voxelized point cloud into compact representation using Point Transformer for bandwidth efficient sharing and more informed driving.

Waymo LLC., *Perception Intern*

Mountain View, CA, Summer 2021

- Developed a deep learning network for segmentation problems using LIDAR point clouds (details confidential).

Microsoft Research, *Collaborator, Research Intern*

Redmond, WA, 2017~2019

- Developed automated crowdsourcing platform, [Satyam](#), for machine vision groundtruth collection at scale.
- Designed annotation quality control framework for complex vision tasks such as detection, tracking, and segmentation to produce high quality labels in face of untrained workers, human errors, and spammers.
- Built world's largest trans-seasonal detection and tracking dataset, [FourSeasons](#), that captures long term seasonal and diurnal variations with traffic surveillance cameras videos spanning over a year.
- Designed active labeling, [MCAL](#), a hybrid human-machine labeling framework, to reduce the annotation cost using machine labeling while balancing training and labeling cost. [Integrated into [Microsoft Azure ML](#)]

IBM Research, *Research Intern*

Yorktown Heights, NY, Summer 2015

- Devised collaborative video analytics system, [Kestrel](#), that tracks vehicle in a heterogeneous camera network.
- Optimized deep neural network to execute on mobile devices to detect objects, extract features, and resolve path ambiguities by careful association in real-time, reducing mobile energy budget by an order of magnitude.

PUBLICATION

Preprints

- [1] [WOMD-LiDAR: Raw Sensor Dataset Benchmark for Motion Forecasting](#)
Kan Chen, Runzhou Ge, **Hang Qiu**, Rami Ai-Rfou, Charles R. Qi, Xuanyu Zhou, Zoey Yang, Scott Ettinger, Pei Sun, Zhaoqi Leng, Mustafa Mustafa, Ivan Bogun, Weiyue Wang, Mingxing Tan, and Dragomir Anguelov

Refereed Publication

- [1] [MCAL: Minimum Cost Human-Machine Active Labeling](#)
Hang Qiu, Krishna Chintalapudi, and Ramesh Govindan
Proceedings of the Eleventh International Conference on Learning Representations (ICLR '23), 2023
- [2] [AutoCast: Scalable Infrastructure-less Cooperative Perception for Distributed Collaborative Driving](#)
Hang Qiu, Pohan Huang, Nam Asavisanu, Xiaochen Liu, Konstantinos Psounis, and Ramesh Govindan
Proceedings of the 20th Annual International Conference on Mobile Systems, Applications, and Services (MobiSys '22), 2022

- [3] [Coopernaut: End-to-End Driving with Cooperative Perception for Networked Vehicles](#)
Hang Qiu*, Jiaxun Cui*, Dian Chen, Peter Stone, and Yuke Zhu
Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR '22), 2022
- [4] [ML-EXray: Visibility into ML Deployment on the Edge](#)
Hang Qiu, Ioanna Vavelidou, Jian Li, Evgenya Pergament, Pete Warden, Sandeep Chinchali, Zain Asgar, and Sachin Katti
Proceedings of Machine Learning and Systems (MLSys '22), 2022 - *Outstanding Paper Award*
- [5] [Sensing the Sensor: Estimating Camera Properties with Minimal Information](#)
Pradipta Ghosh, Xiaochen Liu, **Hang Qiu**, Marcos A. M. Vieira, Gaurav S. Sukhatme, and Ramesh Govindan
ACM Transactions on Sensor Networks (TOSN '22). 2022
- [6] [Optimal Resource Allocation for Crowdsourced Image Processing](#)
Kristina Sorensen Wheatman, Fidan Mehmeti, Mark Mahon, **Hang Qiu**, Kevin S. Chan, and Thomas F. La Porta
IEEE Transactions on Mobile Computing (TMC '22). 2022
- [7] [CarMap: Fast 3D Feature Map Updates for Automobiles](#)
Fawad Ahmad, **Hang Qiu**, Ray Eells, Fan Bai, and Ramesh Govindan
Proceedings of the 17th Symposium on Networked Systems Design and Implementation (NSDI '20), 2020
- [8] [FedML: A Research Library and Benchmark for Federated Machine Learning](#)
Chaoyang He, Songze Li, Jinhyun So, Mi Zhang, Hongyi Wang, Xiaoyang Wang, Praneeth Vepakomma, Abhishek Singh, **Hang Qiu**, Li Shen, et al.
Proceedings of the 34th Conference on Neural Information Processing Systems (NeurIPS '20), *Workshop on Scalability, Privacy, and Security in Federated Learning (NeurIPS '20-SpicyFL)*, 2020 - *Best Paper Award*
- [9] [Optimal Resource Allocation for Crowdsourced Image Processing](#)
Kristina Sorensen Wheatman, Fidan Mehmeti, Mark Mahon, **Hang Qiu**, Kevin Chan, and Thomas La Porta
Proceedings of the 17th Annual IEEE International Conference on Sensing, Communication, and Networking (SECON '20), 2020
- [10] [On Tracking Realistic Targets in a Megacity with Contested Air and Spectrum Access](#)
Jongdeog Lee, Tarek Abdelzaher, **Hang Qiu**, Ramesh Govindan, Kelvin Marcus, Reginald Hobbs, Niranjana Suri, and Will Dron
Proceedings of the 37th Military Communications Conference (MILCOM '18), 2018
- [11] [AVR: Augmented Vehicular Reality](#)
Hang Qiu, Fawad Ahmad, Fan Bai, Marco Gruteser, and Ramesh Govindan
Proceedings of the 16th Annual International Conference on Mobile Systems, Applications, and Services (MobiSys '18), 2018 - *Best Paper Runner-up Award*
- [12] [Kestrel: Video analytics for augmented multi-camera vehicle tracking](#)
Hang Qiu, Xiaochen Liu, Swati Rallapalli, Archith J Bency, Kevin Chan, Rahul Uргаonkar, BS Manjunath, and Ramesh Govindan
Proceedings of the 3rd IEEE/ACM International Conference on Internet-of-Things Design and Implementation (IoTDI '18), 2018
- [13] [Augmented Vehicular Reality: Enabling Extended Vision for Future Vehicles](#)

Hang Qiu, Fawad Ahmad, Ramesh Govindan, Marco Gruteser, Fan Bai, and Gorkem Kar
Proceedings of the 18th International Workshop on Mobile Computing Systems and Applications (HotMobile '17), 2017

[14] [Towards Robust Vehicular Context Sensing](#)

Hang Qiu, Jinzhu Chen, Shubham Jain, Yurong Jiang, Matt McCartney, Gorkem Kar, Fan Bai, Donald K Grimm, Marco Gruteser, and Ramesh Govindan
IEEE Transactions on Vehicular Technology (TVT). 2017

[15] [High-Rate WiFi Broadcasting in Crowded Scenarios via Lightweight Coordination of Multiple Access Points](#)

Hang Qiu, Konstantinos Psounis, Giuseppe Caire, Keith M. Chugg, and Kaidong Wang
Proceedings of the 17th ACM International Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc '16), 2016

[16] [CARLOC: Precise Positioning of Automobiles](#)

Yurong Jiang, **Hang Qiu**, Matthew McCartney, Gaurav Sukhatme, Marco Gruteser, Fan Bai, Donald Grimm, and Ramesh Govindan
Proceedings of the 13th ACM Conference on Embedded Networked Sensor Systems (SenSys '15), 2015

[17] [CARLOG: A Platform for Flexible and Efficient Automotive Sensing](#)

Yurong Jiang, **Hang Qiu**, Matthew McCartney, William G. J. Halfond, Fan Bai, Donald Grimm, and Ramesh Govindan
Proceedings of the 12th ACM Conference on Embedded Network Sensor Systems (SenSys '14), 2014

Technical Reports

[1] [On Localizing a Camera from a Single Image](#)

Pradipta Ghosh, Xiaochen Liu, **Hang Qiu**, Marcos AM Vieira, Gaurav S Sukhatme, and Ramesh Govindan
ArXiv, 2020

[2] [Satyam: Democratizing Groundtruth for Machine Vision](#)

Hang Qiu, Krishna Chintalapudi, and Ramesh Govindan
Integrated into Microsoft Azure ML. Used by UCSB, USC, UIUC, ARL., 2018
Featured in Microsoft Ignite 2019

[3] [Flexible and Efficient Sensor Fusion for Automotive Apps](#)

Yurong Jiang, **Hang Qiu**, Matthew McCartney, William GJ Halfond, Fan Bai, Donald Grimm, and Ramesh Govindan
Citeseer, 2013

Invited Articles

[1] [Augmented Vehicular Reality: Enabling Extended Vision for Future Automobiles](#)

Hang Qiu, Fawad Ahmad, Fan Bai, Marco Gruteser, and Ramesh Govindan
GetMobile: Mobile Comp. and Comm., 2019
Invited article (Best Paper runner-up of Mobisys'18)

[2] [QuickSketch: Building 3D Representations in Unknown Environments using Crowdsourcing](#)

Fawad Ahmad, **Hang Qiu**, Xiaochen Liu, Fan Bai, and Ramesh Govindan

[3] [My Story with ICM](#)

Xilun Chen, **Hang Qiu**, and Chunzhi Yang

UMAP Journal 34.2 & 34.3 Summer Fall 2013 Edition - The 2013 MCM ICM Contest Edition, 2013

Invited article (Outstanding Winner of ICM'12)

PATENTS

[1] [Method and Apparatus for a Context-aware Crowd-sourced Sparse High Definition Map](#)

Fawad Ahmad, **Hang Qiu**, Ramesh Govindan, Donald K Grimm, and Fan Bai

- *Worldwide Patent*: US20200278217 / CN111638536 / DE102020102725

[2] [Crowd-sensed Point Cloud Map](#)

Fawad Ahmad, **Hang Qiu**, Fan Bai, and Ramesh Govindan

- *Worldwide Patent*: US20190266748 / CN110186467 / DE102019104482

[3] [Method and Apparatus of Networked Scene Rendering and Augmentation in Vehicular Environments in Autonomous Driving Systems](#)

Hang Qiu, Ramesh Govindan, Marco Gruteser, and Fan Bai

- *Worldwide Patent*: US20180261095 / CN108574929 / DE102018105293

[4] [Energy-efficient Cooperative Sensing Schedule for Heterogeneous Users in Cognitive Radio Network](#)

Xin Huang, Xinxin Feng, **Hang Qiu**, Gaofei Sun, Xiaohua Tian, Feng Yang, and Xinbing Wang

- *Patent*: CN102905381

[5] [Greedy Channel-allocation in Multi-radio Multi-channel Multi-hop Wireless Network](#)

Hang Qiu, Xin Huang, Qi Shi, Xinbing Wang, and Jun Tian

- *Patent*: CN103634846

[6] [Automatic Line-tracking Floor Waxing Machine](#)

Hang Qiu and Xin Huang

- *Patent*: CN202458213

PRESENTATIONS

Scene Understanding beyond the Visible

International Conference on Learning Representations (ICLR), Kigali, Rwanda, Virtual May 2023

MCAL: Minimum-Cost Human Machine Active Labeling

International Conference on Learning Representations (ICLR), Kigali, Rwanda, Virtual May 2023

ML-EXray: Visibility into ML Deployment on the Edge

University of California, San Diego, California, USA Sep 2022

MLSys Conference, Santa Clara, USA Aug 2022

University of California, Irvine, California, USA Mar 2022

Stanford University, Stanford, California, USA Feb 2022

AutoCast: Scalable Infrastructure-less Cooperative Perception for Distributed Collaborative Driving

IEEE MFI, 1st Cooperative Perception Workshop, Virtual Sep 2022

ACM Mobisys, Portland, USA Jun 2022

Towards Ultra-reliable Cooperative Autonomous Systems

Meta, Reality Lab, Menlo Park, Virtual Apr 2022

University of California, Riverside, California, USA Mar 2022

Yale University, Virtual Feb 2022

University of California, San Diego, Virtual Feb 2022

University of California, Irvine, Virtual Apr 2020

Duke University, Virtual Mar 2020

3D Sensing for Autonomous Robots and Smart Infrastructure

IEEE SmartComp Tutorial, Virtual Aug 2021

AVR: Augmented Vehicular Reality

Intel's Autonomous Driving CoP Workshop, Santa Clara, California, USA Oct 2018

Semiconductor Research Corporation (SRC), TechCon, Austin, Texas, USA Sep 2018

John Hopcroft Center, Shanghai Jiao Tong University, Shanghai, China Jun 2018

ACM Mobisys, Munich, Germany Jun 2018

CONIX Research Center Workshop, San Diego, California, USA Jan 2018

ACM HotMobile, Sonoma, California, USA Feb 2017

Kestrel: Video Analytics for Augmented Multi-Camera Vehicle Tracking

ACM/IEEE IoTDI, Orlando, Florida, USA Apr 2018

High-Rate WiFi Broadcasting in Crowded Scenarios via Lightweight Coordination of Multiple APs

ACM MobiHoc, Paderborn, Germany Jul 2016

SERVICES

Conference Reviewer

USENIX Symposium on Networked Systems Design and Implementation (*NSDI*)

ACM International Conference on Mobile Systems, Applications, and Services (*MobiSys*)

IEEE/CVF Computer Vision and Pattern Recognition Conference (*CVPR*)

IEEE/CVF International Conference on Computer Vision (*ICCV*)

Conference on Robotic Learning (*CoRL*)

IEEE International Conference on Robotics and Automation (*ICRA*)

AAAI Conference on Artificial Intelligence (*AAAI*)

IEEE Conference on Computer Communications (*INFOCOM*)

ACM/IEEE Symposium on Edge Computing (*SEC*)

ACM International Conference on Information Processing in Sensor Networks (*IPSN*)

IEEE International Conference on Sensing, Communication and Networking (*SECON*)

IEEE Vehicular Networking Conference (*VNC*)

IEEE International Conference on Parallel and Distributed Systems (*ICPADS*)

Journal Reviewer

IEEE Transactions on Networking (TON)
IEEE Network Magazine
IEEE Journal on Selected Areas in Communications (JSAC)
IEEE Transactions on Vehicular Technology (TVT)
IEEE Robotics and Automation Letters (RA-L)
IEEE Transactions on Mobile Computing (TMC)
IEEE Access
IEEE Transactions on Cloud Computing (TCC)

Tutorial Organizer

3D sensing for autonomous robots and smart infrastructure, *IEEE SmartComp '21*

SIGMOBILE YouTube Channel

HotMobile'17, Mobicom'16, Mobihoc'16, Sensys'16

TEACHING AND MENTORING

Teaching

Co-instructor, *ML on Embedded Systems (Stanford EE 292D)*, Co-Instructor: S.Katti, Z.Asgar, P.Warden Fall 2021
Teaching Assistant, *Wireless Networks (USC ECE 597)*, Instructor: B. Krishnamachari Spring 2020
Teaching Assistant, *Computer Communications (USC CSCI 551)*, Instructor: R. Govindan Fall 2017
Guest Lecturer, *Wireless Networks (USC ECE 597)*, Instructor: K. Psounis Spring 2020
Guest Lecturer, *Wireless Networks (USC ECE 597)*, Instructor: K. Psounis Spring 2015
Panelist, *Seminar in Computer Science Research (USC CSCI 697)*, Instructor: L. Golubchik Spring 2019

Mentoring

Jiaxun Cui (PhD): *Collaborative Autonomous Driving (CVPR '22)* 2020~pres.
Namo Asavisanu (PhD): *Scalable Cooperative Perception (Mobisys '22)* 2020~pres.
Ioanna Vavelidou (PhD): *Edge ML Monitoring and Debugging (MLSys '22)* Fall 2021
Fawad Ahmad (PhD): *Fast 3D Feature Map Updates for Automobiles (NSDI '20)* 2016~2020
Ray Eells (BS): *Autonomous Vehicle Control using Extended Vision* 2018~2020
Meghraj Bendre (MS): *Understanding Computer Vision Robustness under Seasonal Changes* Summer 2018
Jens Windau (PhD): *Human Pose and Gesture Monitoring using Wearable Sensors* Fall 2016
Bhavana Srinivas (MS): *Improving Campus WiFi Service* Fall 2014

HONORS AND AWARDS

Outstanding Paper Award, *MLSys 2022, Santa Clara, USA* 2022
Outstanding Research Assistant Award, *USC* 2021
Qualcomm Innovation Fellowship, Finalist, *San Diego, USA* 2019
Best Paper Award, runner-up, *ACM Mobisys 2018, Munich, Germany* 2018
Viterbi Graduate Student Annenberg Fellowship, *USC* 2013~2017
Outstanding Winner, *Interdisciplinary Contest in Modeling (ICM), USA* 2012
National Fellowship (Top 1%), *China* 2010, 2011, 2012
First-Class (Top 1%) Academic Excellence Fellowship, *Shanghai Jiao Tong University* 2010, 2011, 2012
Academic Star (Top 1%), *Shanghai Jiao Tong University* 2012
NSF/SIGMOBILE Travel Grants, *ACM Mobicom'16, ACM Sensys'16, ACM HotMobile'17*

SOFTWARE AND DATASET

- [1] AutoCast Github: <https://github.com/hangqiu/AutoCast>
- [2] Coopernaut Github: <https://github.com/UT-Austin-RPL/Coopernaut>
- [3] Coopernaut Website and Dataset: <https://ut-austin-rpl.github.io/Coopernaut/>
- [4] ML-EXray Github: <https://github.com/hangqiu/ML-EXray>
- [5] CarMap Github: <https://github.com/USC-NSL/CarMap>
- [6] FourSeasons Dataset and Benchmark: <https://trafficcamedataset.wordpress.com/>
- [7] Satyam Github: <https://github.com/satyamresearch/satyam>
- [8] AVR Github: <https://github.com/hangqiu/AVR16>