

Lei Fan

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EDUCATION

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- **Northwestern University** Evanston, IL, United States
M.S., Ph.D. candidate in Electrical Engineering, advised by Prof. Ying Wu 2019 - 2024
 - **Sun Yat-sen University** Guangzhou, China
B.E., M.S. in Computer Science, advised by Prof. Long Chen 2013 - 2019

RESEARCH INTERESTS

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- **Embodied active vision**
Involving intelligent control strategies into the embodied agents to handle different visual perception challenges.
 - **Vision-language foundation models**
Developing vision-language foundation models for embodied perception and question answering.
 - **Evidential uncertainty estimation for visual perception**
Enabling vision models to say "I do not know", especially for robotic perception in open-world scenarios.

PUBLICATIONS

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- [1] **Lei Fan**, Jianxiong Zhou, Xiaoying Xing, Ying Wu, "Active Open-Vocabulary Recognition: Let Intelligent Moving Mitigate CLIP Limitations", accepted by IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), 2024.
- [2] **Lei Fan**, Mingfu Liang, Yunxuan Li, Gang Hua, Ying Wu, "Evidential Active Recognition: Intelligent and Prudent Open-World Embodied Perception", accepted by IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), 2024.
- [3] **Lei Fan**, Bo Liu, Haoxiang Li, Ying Wu, Gang Hua, "Flexible Visual Recognition by Evidential Modeling of Confusion and Ignorance", accepted by the IEEE International Conference on Computer Vision (ICCV), 2023.
- [4] **Lei Fan**, Ying Wu, "Avoiding Lingering in Learning Active Recognition by Adversarial Disturbance", accepted by IEEE/CVF Winter Conference on Applications of Computer Vision (WACV), 2023.
- [5] **Lei Fan**, Yunxuan Li, Chen Jiang, Ying Wu, "Unsupervised Depth Completion and Denoising for RGB-D Sensors", accepted by IEEE International Conference on Robotics and Automation (ICRA), 2022.
- [6] **Lei Fan**, Peixi Xiong, Wei Wei, Ying Wu, "FLAR: A Unified Prototype Framework for Few-sample Lifelong Active Recognition", accepted by the IEEE International Conference on Computer Vision (ICCV), 2021.
- [In submission] Xiaoying Xing, Peixi Xiong, **Lei Fan**, Yunxuan Li, Ying Wu, "L2A: Learn to Actively Ask Questions"
- **Before my Ph.D. (Topics: Perception for Autonomous Driving, 3D Scene Understanding, etc)**
- [7] Yucai Bai, **Lei Fan**, Ziyu Pan, and Long Chen, "Monocular Outdoor Semantic Mapping with a Multi-task Network", accepted by IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2019.
- [8] **Lei Fan**, Long Chen, Chaoqiang Zhang, Wei Tian, and Dongpu Cao, "Collaborative 3D Completion of Color and Depth in a Specified Area with Superpixels", accepted by IEEE Transactions on Industrial Electronics, 2018.
- [9] **Lei Fan**, Long Chen, Kai Huang and Dongpu Cao, "Planecell: Representing Structural Space with Plane Elements", accepted as **Best Student Paper** by IEEE Intelligent Vehicles Symposium, 2018.
- [10] Long Chen, Yuhang He, and **Lei Fan**, "Let the Robot Tell: Describe Car Image with Natural Language via LSTM", accepted by Pattern Recognition Letters, 2017.
- [11] Long Chen, **Lei Fan**, Guodong Xie, Kai Huang, and Andreas Nuchter, "Moving-Object Detection from Consecutive Stereo Pairs using Slanted Plane Smoothing", accepted by IEEE Transactions on Intelligent Transportation Systems, 2017.
- [12] Long Chen, Libo Sun, Teng Yang, **Lei Fan**, Kai Huang, and Zhe Xuanyuan, "RGB-T SLAM: A Flexible SLAM Framework by Combining Appearance and Thermal Information", accepted by IEEE International Conference on Robotics and Automation (ICRA), 2017.

RECENT RESEARCH PROJECTS

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- **Active Open-Vocabulary Recognition**
 - Investigate CLIP limitations in embodied perception scenarios, and develop an open-vocabulary recognition agent.
 - **Motivations:** 1. Enhance the capabilities of active recognition agents in handling open vocabulary using CLIP.
 - 2. Overcome the inherent limitations of CLIP in unconstrained embodied perception scenarios.

- **Details:** a. Establish the open-vocabulary active recognition task, addressing a gap in current embodied perception challenges. b. Evaluate the performance of current visual-language models within embodied perception contexts, identifying their susceptibility to changes in viewpoints and levels of occlusion. c. Implement an intelligent control strategy for the embodied agent, enabling it to seek out more informative perspectives during the recognition process. A semantic-agnostic information fusion module is also proposed to maintain generalization capabilities.
- **Evidential Active Recognition**
Quantify uncertainties and mitigate their adverse effects for embodied agents in open environments.
 - **Motivations:** Unexpected visual observations often occur when the robot is exploring the environment, which bring negative impacts to embodied agents.
 - **Details:** 1. Introduce the first publicly available dataset for evaluating active recognition. Each testing sample is paired with a recognition difficulty level to more effectively illustrate the benefits of active recognition. 2. Develop an evidence-based active recognition agent that incorporates sequential information while accounting for uncertainty levels, thereby mitigating the impact of unforeseen negative inputs.
- **Flexible Visual Recognition by Evidential Modeling Uncertainties**
Modeling uncertainties in visual recognition from two distinct sources, confusion and ignorance.
 - **Motivations:** In real-world scenarios, recognition could fail under two major causes. 1. Misclassification between known classes (confusion). 2. Misbehavior on unknown-class images (ignorance). We want to quantify both uncertainties in a sample-wise manner.
 - **Details:** We develop our method under the theory of Subjective Logic. Confusion is the shared evidence contributing to multiple categories while not discriminative between them, while ignorance is completely missing evidence. During training, the model learns the Dirichlet prior placed on singleton classes. Confusion and ignorance could then be obtained through the evidence combination theory.

WORK EXPERIENCE

- **Amazon Robotics** Seattle, WA, United States
Applied Scientist Intern *June 2023 - Sep. 2023*
 - **Topic:** Monocular surface normal estimation. Item placement stability analysis for fulfillment centers.
 - **Details:** Leverage advanced deep vision models to interpret and reconstruct scene structures from a singular image, enhancing robotic guidance for stable item placements.
- **Wormpex AI Research** Bellevue, WA, United States
Research Intern *June 2022 - Sep. 2022*
 - **Topic:** Uncertainty quantification for deep visual recognition.
 - **Details:** a. Reviewing recent studies on recent deep uncertainty estimations, including Bayesian-based and evidence-based methods. Conducting various experiments on recent uncertainty estimation methods and also relevant applications, like active learning and open-set recognition. b. Propose an approach to estimate ignorance and confusion at the same time. The method is established under the Dempster-Shafer theory and subjective logic. Opinions are then developed by doing evidence combinations.
- **Yosion Analytics** Chicago, IL, United States
Research Intern *June 2020 - Sep. 2020*
 - **Topic:** Autonomous forklift in a human-machine co-working environment.
 - **Details:** a. Developing a camera-based pallet recognition and localization system for precise autonomous pallet lifting. b. Developing a vision-based empty pallet space detection system that could be used under changing lighting conditions. The system runs on a Raspberry Pi in real time.
- **DJI** Shenzhen, China
Visual Engineer Intern *June 2016 - Sep. 2016*

SELECTED SCHOLARSHIPS & HONORS

- **Northwestern University Murphy Fellowship** 2019-2020
- **Best Student Paper, IEEE Intelligent Vehicle Symposium** 2018
- **National Merit Scholarship, China** 2018

TEACHING EXPERIENCES

- **Teaching Assistant** Introduction to Computer Vision, Advanced Computer Vision, Linear Algebra.

ACADEMIC SERVICES

- **Invited Conference & Journal Reviewer** CVPR, ICCV, ECCV, WACV, ICRA, IROS, IV, NeurIPS, ICPR, T-PAMI, IJCV, etc.