Lei Fan

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EDUCATION

- **Northwestern University** — Evanston, IL, United States
  M.S., Ph.D. candidate in Electrical Engineering, advised by Prof. Ying Wu — *Sep. 2019 - June 2024 (Expected)*
- **Sun Yat-sen University** — Guangzhou, China
  M.S. in Computer Science, advised by Prof. Long Chen — *Sep. 2017 - June 2019*
- **Sun Yat-sen University** — Guangzhou, China
  B.E. in Computer Science — *Sep. 2013 - June 2017*

RESEARCH INTERESTS

- **Active vision**
  Involving intelligent control strategies into the visual recognition process to handle different recognition challenges.
- **Uncertainty estimation for classification models**
  Enabling classification models to say "I do not know", especially for robots in open-world scenarios.
- **Vision-language foundation models**
  Investigating and employing vision-language foundation models for embodied perception and question answering.

PUBLICATIONS

[1] **Lei Fan**, Jianxiong Zhou, Xiaoying Xing, Ying Wu, "**Active Open-Vocabulary Recognition: Let Intelligent Moving Mitigate CLIP Limitations**", to appear at IEEE/CVF Conference on Computer Vision and Pattern Recognition, 2024.

[2] **Lei Fan**, Mingfu Liang, Yunxuan Li, Gang Hua, Ying Wu, "**Evidential Active Recognition: Intelligent and Prudent Open-World Embodied Perception**", to appear at IEEE/CVF Conference on Computer Vision and Pattern Recognition, 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, 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, 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, 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, 2021.

[In submission] Xiaoying Xing, Peixi Xiong, Yunxuan Li, **Lei Fan**, 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 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, 2017.

RECENT RESEARCH PROJECTS

- **Open-Vocabulary Active Recognition** — Sep. 2023 - Present
  Developing open-vocabulary active recognition agents in simulators.
  - **Motivations:** Most existing active recognition research relies on closed-set toy datasets, such as unoccluded 3D CAD models. Challenges in realistic active recognition, including challenging recognition conditions and open categories, have largely been overlooked, even though they are prevalent in open environments.

- **Details:** a. Defined the open-vocabulary active recognition task, an area not covered in existing embodied perception challenges. Collecting and organizing the datasets for active recognition based on different recognition difficulty levels. b. Created an open-vocabulary recognition agent capable of actively exploring its environment to recognize open-class objects using large language models.

- **Joint Learning of Recognizer and Policy in Active Recognition**   Jan. 2022 - June 2022
Investigating the challenges in concurrently training both vision and policy modules.

  - **Motivations:** Joint learning of two modules, i.e., the recognition module and the policy, could lead to unintended consequences. The policy only visits views that the recognizer is already sufficiently trained to obtain rewards, which hurts its generalization ability during testing.
  - **Details:** The proposed method introduces an adversarial policy to compete with the major recognition policy. During training, the adversarial policy continuously perturbs the agent for more effective and thorough training of both the recognizer and the policy module.

- **Controllable Image Generation for Articulated Objects (Human Body)**   Sep. 2021 - Dec. 2021
Designing a 3D-aware NeRF-based model for articulated objects, primarily the human body.

  - **Motivations:** a. Compared to human image generation methods operating in the 2D domain, synthesizing 3D human models and then projecting to 2D could give a better attribute disentanglement. b. Manipulating articulated objects in 3D provides superior temporal consistency in generated videos.
  - **Details:** The proposed method disentangles the articulated body into a composition model of rigid parts. The movement of each rigid part is detached from a canonical representation. Regid parts are reconstructed with randomness-injected NeRF models. This method is trainable solely on 2D image collections.

- **Active Recognition with Limited Training Samples and Continual Learning**   June 2021 - Dec. 2021
Handling realistic challenges of active recognition during the agent's exploration.

  - **Motivations:** a. Agents may encounter novel objects during exploration. To recognize these, the agent must expand its knowledge base, requiring lifelong or continual learning. b. Newly acquired object categories often lack extensive labeled data. How can one devise active recognition strategies under limited data settings?
  - **Details:** a. Developed a rehearsal-based active recognition strategy using limited exemplar memory. Forgetting is mitigated using distillation loss on stored exemplars. A center-based classification approach addresses the challenge of limited training samples. b. Experiments span both object and scene recognition.

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, Mentor: Dr. Bo Liu, Dr. Haoxiang Li, and Dr. Gang Hua   June 2022 - Sep. 2022

  - **Topic:** Uncertainty quantification for deep visual recognition.
  - **Details:** a. Reviewing recent studies on recent deep uncertainty estimations, including Baysian-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 Depmster-Shafer theory and subjective logic. Opinions are then developed by doing evidence combinations.

- **Yosion Analytics**   Chicago, IL, United States
Research Intern, Mentor: Dr. Nan Jiang   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

ACADEMIC SERVICES

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