Lu Wen

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EDUCATION

University of Michigan, Ann Arbor, MI, USA
Ph.D. of Mechanical Engineering *June 2024*
Master of Mechanical Engineering *Apr. 2020*
Supervised by: Prof. Huei Peng, VDLab
Tsinghua University, China *July 2018*
Bachelor, Department of Automotive Engineering, School of Mechanical Engineering
Supervised by: Prof. Shengbo Eben Li, iDLAB

EXPERIENCE

Tiktok, San Jose, CA
Machine Learning Engineer: E-commerce Feed Recommendation *July. 2024- Now*
- Improve models and algorithms used in different parts of the e-commerce recommendation system. Selected projects include:
- Increasing author post by 2.5% through introducing binding-related behavioral features;
- Improving efficiency of cold-start by 5.72%(GPM) through using multi-modal similarity measurement among products;
- Measuring a scarcity score of products to exploit gmv's growth potentials.

Honda Research Institution, Ann Arbor, MI
Research Intern: driving behavior model for autonomous driving *Jan. 2024- April. 2024*
- Develop a driving behavior model using real world driving data.
- Integrate a developed driver behavior model into a simulator to support high-fidelity ADAS/AD technology software testing.
- Evaluate the developed driving models against existing state of the art models from literature.

Nuro, Inc., Mountain View, CA
Research Intern: causal imitation learning for autonomous driving *May. 2023- Sept. 2023*
- Proposed a causal imitation learning-based planner for autonomous driving, which aims to improve the planning's performance in terms of generalization and causality.
- Introduced domain knowledge in autonomous driving to imitation learning from observational data, helping to relieve causal fallacies especially between environmental context features and other agents' features in the scenario.
- The proposed solution was tested on Nuro's inner evaluation dataset and metrics: increased 5% passing rates, reduced 5-15% average displacement error (ADE), and got a more assertive policy according to manual triaging.

Ford Motor Company, Dearborn, MI
Research Intern: reinforcement-learning-based eco-driving in urban traffic *Jun. 2019- Aug. 2019*
- Proposed a deep reinforcement learning-based solution for eco-driving in an urban traffic network in presence of signalized lights, relieving the high online computation cost problem of previous optimization approaches like dynamic programming.
- This reinforcement learning-based solution formulated the eco-driving problem as a constrained MDP, taking some limitations, e.g. control actuators limits and speed limits as hard constraints.
- The proposed solution consumed energy of only 5.7% higher than that of dynamic programming, which is regarded as the global optimal solution or upper bound.

University of California, Berkeley, California, CA
Visiting Scholar to MSC Lab: realized trajectory tracking of an automated Lincoln MKZ *Jun. 2017- Sept. 2017*
- State estimation: Extended Kalman Filter is applied to obtain nonlinear estimation, based on DGPS and IMU.
- Vehicle control: optimal control and Model Predictive Control are implemented to achieve desirable control performances.
- Implemented the techniques above on an automated Lincoln MKZ to track any given trajectories.

RESEARCH PROJECTS

■ PLANNING & DECISION-MAKING

Meta Reinforcement Learning for decision-making in autonomous driving *2021-current*
- Developed a novel context-based Meta RL algorithm, PEARL+ algorithm, which optimizes the policy for both prior safety and posterior adaptation by introducing a prior regularization term in the reward function and new Q-network for recovering the state-action value with prior context assumptions. This algorithm is compatible to most state-of-the-art meta-reinforcement-learning algorithms and proved to significantly improve the prior policy safety.
- Proposed another meta-reinforcement learning algorithm, MetaDreamer, that requires less real training tasks and data by doing

meta-imagination and MDP-imagination for controllable data generation. We perform meta-imagination by interpolating on the learned latent context space with disentangled properties, as well as MDP-imagination through the generative world model where physical knowledge is added to plain VAE networks.

- Apply these meta reinforcement learning approaches to real autonomous driving problems, improving the generalization and robustness of the decision-making in representative autonomous driving scenarios.

Safe Reinforcement Learning and its application to autonomous driving *Feb. 2017-Jun. 2019*

- Proposed the *Parallel Constrained Policy Optimization (PCPO)* algorithm, which introduces a risk network to evaluate the risk of states and actions.
- PCPO algorithm improves the data efficiency and learning speed, promoting the application of reinforcement learning to realistic autonomous driving and related research.
- Applied the PCPO algorithm to autonomous driving scenarios, validating that PCPO can guarantee the safety of the entire learning process of a mature policy and have higher efficiency compared with previous approaches.

Perception, planning and decision at crossroads for Self-driving Vehicles *Jan. 2017-Apr. 2017*

Cooperative project with Huawei Technologies Co. Ltd

- Vehicle dynamics control: leveraged a PID controller, LQR method, and MPC method for vehicle control.
- Trajectory planning: implemented A-star algorithm and defined a Heuristic function reasonably to get optimal solutions.

■ **DYNAMICS & CONTROL**

Control for vehicle stabilization at the limits of handling based on Model Predictive Control *May 2017-Jul. 2017*

(Assistant Research) Supervised by Prof. Shengbo Li, Tsinghua University

- Defined state boundaries that exclude unstable vehicle dynamics.
- Leveraged a model predictive envelope controller to bound the vehicle motion within the stable region of the state space.

PUBLICATION

- ***Wen, L.****, Tseng, E. H., Peng, H., & Zhang, S., 2024. Dream to adapt: Meta reinforcement learning by latent context imagination and MDP imagination. IEEE Robotics and Automation Letters.*
- ***Wen, L.,*** *Zhang, S., Tseng, H. E., and Peng, H., Quickly Adaptive Automated Vehicle's Highway Merging Policy Synthesized by Meta Reinforcement Learning with Latent Context Imagination. The 2nd International Conference on Cognitive Computation and Systems (ICCCS 2023)* **(best paper)**
- ***Wen, L****., Zhang, S., Tseng, H.E., Singh, B., Filev, D. and Peng, H., 2022, October. Improved Robustness and Safety for Pre-Adaptation of Meta Reinforcement Learning with Prior Regularization. In 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) (pp. 8987-8994). IEEE.*
- *Zhang, S., **Wen, L**., Peng, H. and Tseng, H.E., 2021, September. Quick learner automated vehicle adapting its roadmanship to varying traffic cultures with meta reinforcement learning. In 2021 IEEE International Intelligent Transportation Systems Conference (ITSC) (pp. 1745-1752). IEEE.*
- ***Wen, L.,*** *Duan, J., Li, S.E., Xu, S. and Peng, H., 2020, September. Safe reinforcement learning for autonomous vehicles through parallel constrained policy optimization. In 2020 IEEE 23rd International Conference on Intelligent Transportation Systems (ITSC) (pp. 1-7). IEEE.*
- *Liu, Z., **Wen, L.,** He, Y. and Wei, Y., 2017, December. Three-dimensional free vibration of tires with the laminated composite Timoshenko beam theory. In INTER-NOISE and NOISE-CON Congress and Conference Proceedings (Vol. 255, No. 4, pp. 3169-3179). Institute of Noise Control Engineering.*

SELECTED AWARDS

- Rackham Doctoral Internship Fellowship, University of Michigan *2023*
- William Mirsky Memorial Fellowship, University of Michigan *2019*
- Tsinghua's Friend- Gao Tian 1st prize Scholarship for Overall Excellence, Tsinghua *2014- 2016*
- 4th place in 10th Intelligent Car Competition, Tsinghua University *2015*
- Outstanding Student of 2014 *2014*

SKILLS

- **Programming languages**: Python, C/C++, MATLAB.
- **Frameworks:** PyTorch, TensorFlow, RLlib. **System:** Mac, Windows, Linux.
- **Simulation:** OpenAI Gym, MuJoCo, Isaac Gym, CARLA, SUMO, Gazebo, ROS2
- **Hardware:** Autonomous vehicle onboard development, MCU development.
- **Others:** Experience with autonomous vehicle dynamics, sensors, and wireless communication (ROS2).
- **Technical: Machine Learning**: Reinforcement Learning, Imitation Learning, Meta Learning, Causal Learning, Multi-modal Learning, generative models, Transformer, Diffusion model; **Control&Planning**: MPC, LQR, EKF, trajectory optimization.