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Research

Summary: Perception and control of autonomous cars with an emphasis on safety and efficiency. Mixed traffic coordination using Reinforcement Learning (RL) and Computer Vision. Robustness evaluation of deep learning systems in transport.

- **EnduRL: Enhancing Safety, Stability, and Efficiency of Mixed Traffic Via RL** *In Submission*
Measures the Safety, Stability, and Efficiency of car-following models under real-world driving behaviors. Devised an RL vehicle that incorporates neural network classifier to predict congestion early, **improving safety and efficiency up to 54%**.
- **AutoJoin: Efficient Adversarial Training against Gradient-Free Perturbations for Robust Maneuvering** *In Submission*
Augmentation technique for natural corruptions (rain, snow, fog etc.) in Computer Vision based perception in autonomous cars (models: ResNet50, end-to-end CNN from Nvidia) with **improvement in steering angle prediction upto 300%**.
- **CARL: Congestion-Aware RL for Imitation-based Perturbations in Mixed Traffic Control** *IEEE CYBER 2024*
Addresses the *sim-2-real* gap in modeling real-world human driving behaviors in traffic simulation by combining imitation learning and probabilistic sampling. Validated against existing car-following models and evaluated their performance.
- **Mixed Traffic Control and Coordination from Pixels** *ICRA 2024*
Simplified observations in autonomous cars by using bird's-eye view camera, instead of road sensor networks. In mixed traffic control, demonstrated performance similar to perfect observations with **8% improvement in highway merging**.
- **Can ChatGPT Enable Intelligent Transportation Systems? The Case of Mixed Traffic Control via RL** *ITSC 2023*
User study with 70 participants to determine the efficacy of OpenAI's GPT-4 in assisting novices in RL. **GPT-4 increases new metrics utilization by 363%**, and in certain scenarios performance of Novices + GPT-4 is better than expert.
- **Efficient Quality-Diversity Optimization through Diverse Quality Species** *GECCO 2023*
A **novel genetic algorithm with state-of-the-art sample efficiency** in simulated quality-diversity robotic environments. Eliminates the need for maintaining computationally expensive predefined data structures.
- **Learning to Control DC Motor for Micromobility in Real Time with Reinforcement Learning** *ITSC 2022*
Steering angle control of DC motor in simulation and in hardware (attached to a golf-cart). Used NFQ algorithm to learn a **control policy from scratch in 1 minute 35 seconds** in simulation and in 10 minute and 35 seconds in hardware.
- **Black-box Adversarial Attacks on Network-wide Multi-step Traffic State Prediction Models** *ITSC 2021*
Demonstrated adversarial vulnerabilities of deep learning based network-wide traffic state prediction models, **degrading their performance upto 54%**. Demonstrated that traditional modeling techniques offer higher robustness.

Skills

Programming: Python, Java, C++ , Ruby on Rails
Libraries & Frameworks: PyTorch, TensorFlow, Keras, HuggingFace, Weights & Biases, NumPy, Scikit-Learn, Pandas, Matplotlib, Seaborn
Data Science: Data cleaning, exploration, visualization, and statistical analysis
Tools: Git, Docker, Conda, LaTeX

Education

Ph.D. in Computer Science *2023–Present*
University of Tennessee
Knoxville, TN
GPA: 3.83/4.0
Coursework: Foundations, Advanced Software Engineering

M.S. in Computer Science *2019–2023*
University of Memphis
Memphis, TN
GPA: 4.0/4.0
Coursework: Artificial Intelligence, Machine Learning, Reinforcement Learning, Software Engineering

Projects

- **DocuMint: Docstring Generation for Python using Small Language Models** (*Report*) *2024*
Benchmarked small language models on the quality of their generated docstrings, created a fine-tuning dataset using the FOSS ecosystem, and fine-tuned Google's CodeGemma. Released the dataset and the fine-tuned model in [HuggingFace](#).
- **Artificial Intelligence Assignments** (*Repository*) *2023*
Developed and conducted programming assignments for graduate level AI and ML courses at University of Memphis and University of Tennessee. Topics include Deep Q Networks, Proximal Policy Optimization and Finetuning of a Transformer.
- **BarterBaron** (*Demo*) *2022*
Engineered an eBay-like commerce platform based on barter system using Ruby on Rails with features like chat, search, and secure user authentication. **Won "Best project in the class" award**, Software Engineering, University of Memphis.
- **Robustness to Input Corruptions and Adversarial Examples in Steering Angle Prediction** (*Video*) *2022*
Used self-supervised learning to enhance robustness of computer vision models in steering angle prediction, under natural disturbances to camera such as rain, snow, fog, frost, pixelation, and blur.
- **Distributed Hyperparameter Tuning of Neural Networks.** *2021*
Accelerated the hyperparameter tuning (grid and random search) of Multi Layered Perceptrons by upto 80%. Paralellized search objective using Distributed Hash Table, utilizing computational resources in multiple nodes.
- **Latent Representation of Inputs: A Defense Against Adversarial Examples in Deep Q Networks.** (*Report*) *2021*
Used feature squeezing to improve the adversarial robustness of DQN algorithm trained to play Atari Pong.