

Scalable and Customizable Intent Inference and Motion Planning for Socially-Adept Autonomous Vehicles

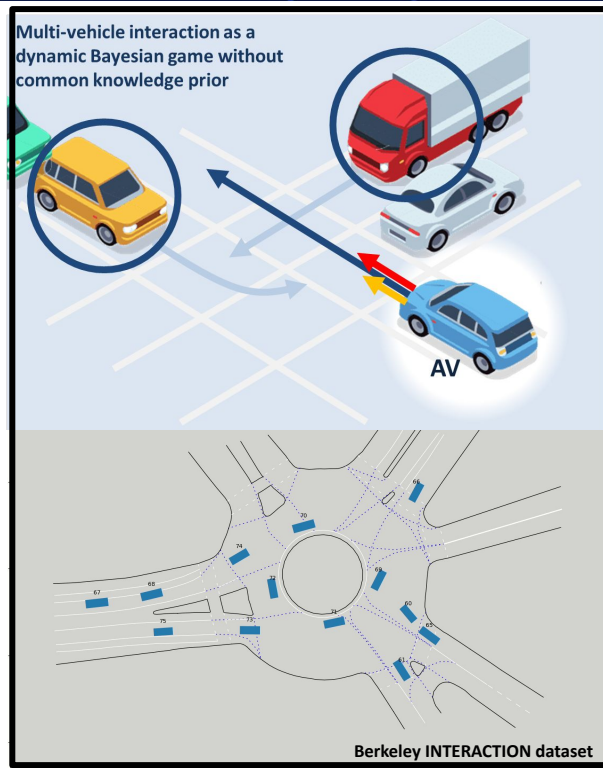
PI: Wenlong Zhang, Co-PIs: Yi Ren, Yezhou Yang. Arizona State University. 2019-2022. (CMMI-1925403)

Challenge

- Interactions are differential games w/ *incomplete-information*
- Computing perfect Bayesian equilibrium (PBE) in real time in computationally expensive
- Application in real-world requires building efficient multi-modal system for the edge-device

Solution

- Real-time equilibrium searching via learning of motion and belief dynamics through traffic data and game theory
- Detector-free and end-to-end Vision Transformer based one-stage multi-modal model



Scientific Impact

- Enable accurate intent inference and effective signaling during multi-agent interactions
- Enable safe and robust interaction via long-term adaptation of social value orientation, common belief, and solution concepts

Broader Impact

- Collaboration with Institute of Automated Mobility/Intel (ongoing)
- 2 REU interns on conf. papers and honor thesis (ongoing)
- Interdisciplinary course on human-robot interaction (in plan)

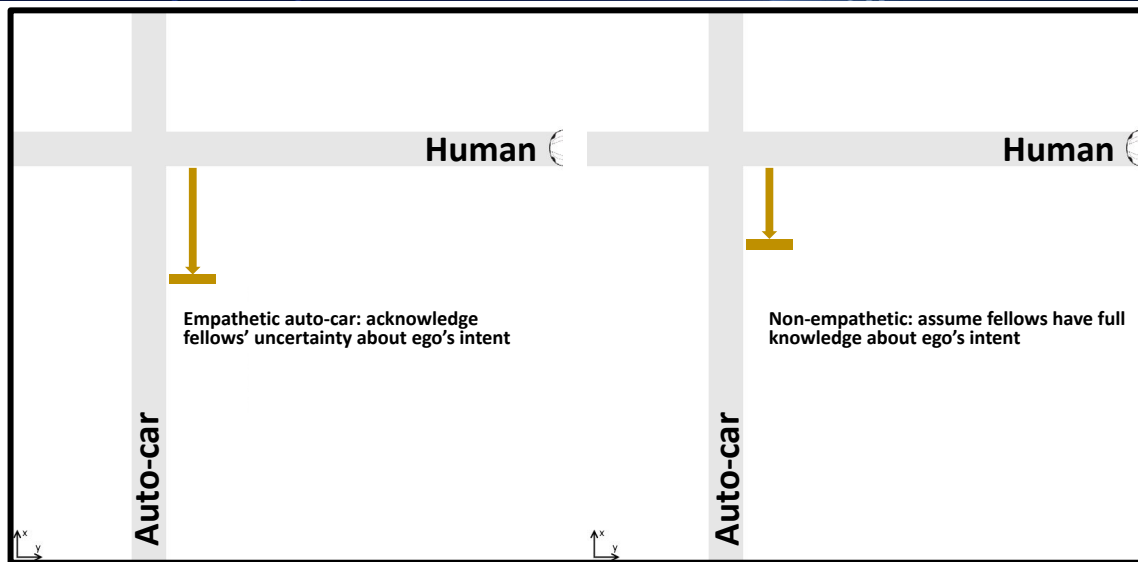
Ongoing work 1: Intent inference & motion planning via equilibrium approximation for incomplete-information games

Contributions to Intent Inference

- Inference via bounded rationality, Bayesian belief update & *equilibrial Hamiltonian approximation*¹
- Hamiltonian incorporates belief uncertainty, approximated via *learning of co-state dynamics*¹

Contributions to Interaction

- *Empathy* improves inference accuracy, especially when agents have biased prior beliefs¹
- *Rational courtesy* is enabled via empathetic intent inference^{2,3}



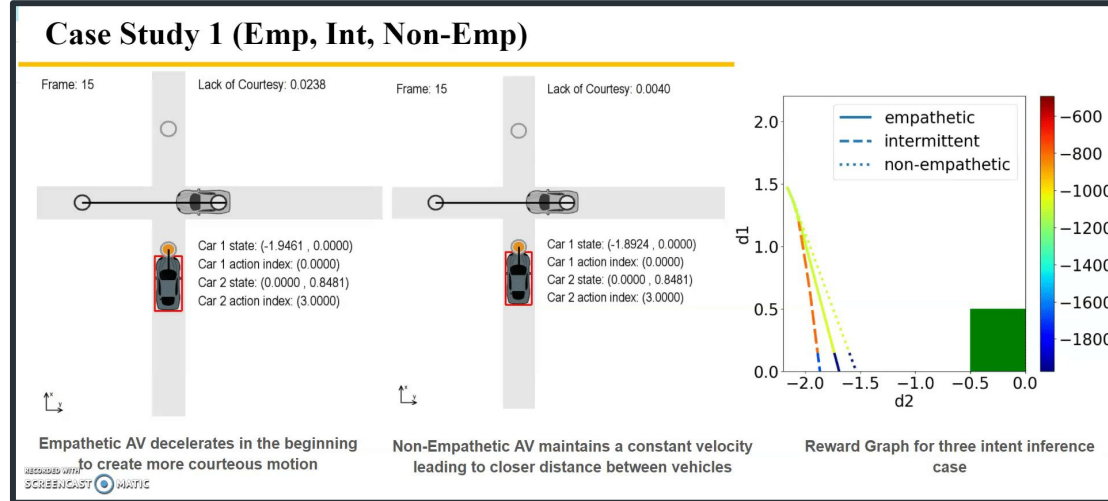
1. Chen, Y., Zhang, L., Merry, T., Amatya, S., Zhang, W., Ren, Y., "When shall I be empathetic? The utility of empathetic parameter estimation in multi-agent interactions", 2021.
2. Wang, Y., Ren, Y., Elliott, S., Zhang, W., "Enabling courteous vehicle interactions through game-based and dynamics-aware intent inference", *IEEE Transactions on Intelligent Vehicles* 5 (2), 217-228 (2020)
3. Ren, Y., Elliott, S., Wang, Y., Yang, Y., Zhang, W., "How shall I drive? Interaction modeling and motion planning towards empathetic and socially-graceful driving", 2019 International Conference on Robotics and Automation (ICRA), 4325-4331

Ongoing work 2: Intermittent Intent Inference via Reinforcement Learning

Ongoing work 3: Building Efficient Multi-modal System

Intermittent Intent Inference

- Insight: Computing intent inference online and at every timestep is computationally expensive and often times do not provide additional information about the system¹
- Influenced by human, RL based intermittent intent inference framework¹
- The framework is able to perform safe maneuvers without computational load¹



Efficient Multi-model System

- Develop an efficient multi-modal system that connects the inputs from Vision and Language, and is not reliant on any object detector so is end-to-end trainable²



Pred. Concept: [wine, motorcycle, stand, bar, shelf, blue ...]
Pred. Caption: A motorcycle parked in front of a bunch of bottles of wine.

- Amatya, S., Ghimire, M., Ren, Y., Xu, Zhe., Zhang, W., "When Shall I Estimate Your Intent? Costs and Benefits of Intent Inference in Multi-Agent Interactions", ACC2022 (accepted)
- Fang, Z., Wang, J., Hu, X., Liang, L., Gan, Z., Wang, L., Yang, Y. and Liu, Z., 2021. "Injecting Semantic Concepts into End-to-End Image Captioning." CVPR 2022