About the team

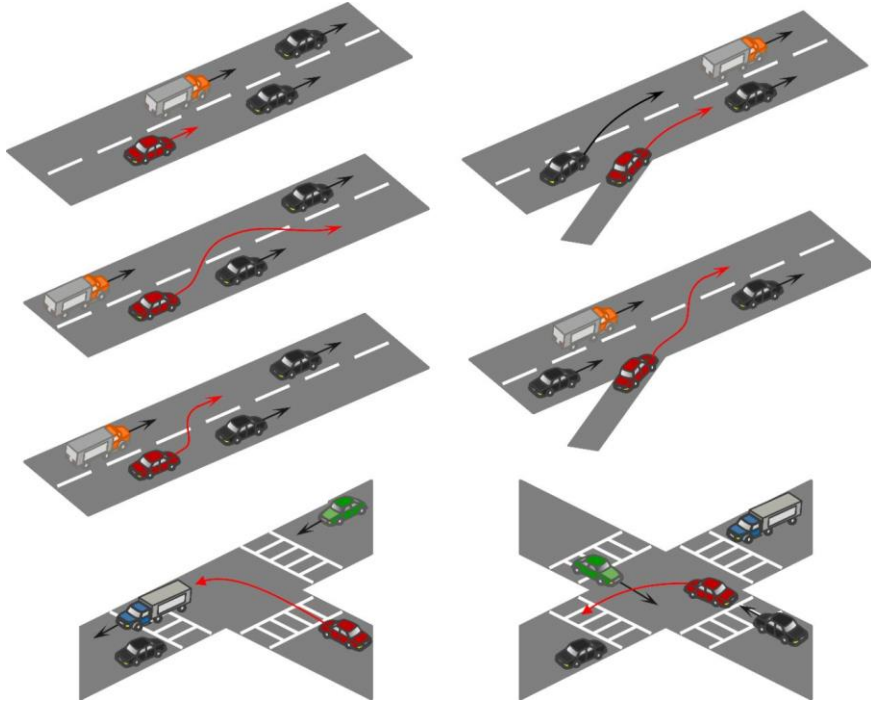Zhiyu Huang   Haochen Liu   Jingda Wu   Chen Lyu

AutoMan **Lab** Intelligent Decision-making (AID) Team

- ❖ Member: Zhiyu Huang, Haochen Liu, Jingda Wu
- ❖ Advisor: Prof. Chen Lyu
- ❖ Lab Homepage: https://lvchen.wixsite.com/automan
- ❖ Project Code: https://github.com/MCZhi/Predictive-Decision

Introduction

Solving real-world autonomous driving

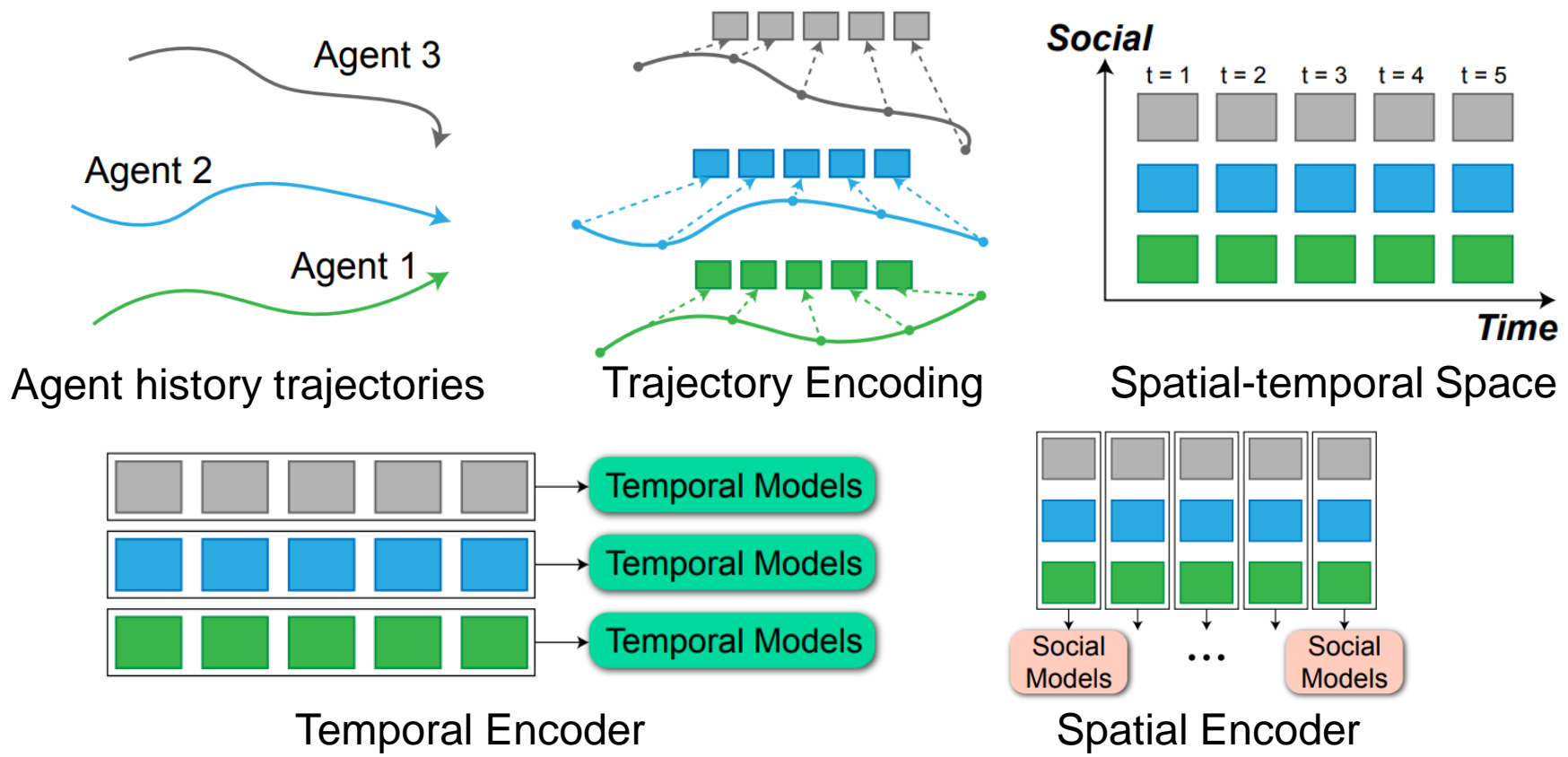## Learning for decision-making

- ***Reinforcement Learning***: good testing performance, low data efficiency, hard-to-tune reward function

- ***Imitation Learning***: efficient training, no reward engineering, poor testing performance due to distributional shift

- ***Model Predictive Control***: better generalization and safety guarantee, high requirements on predictive models (where learning kicks in)
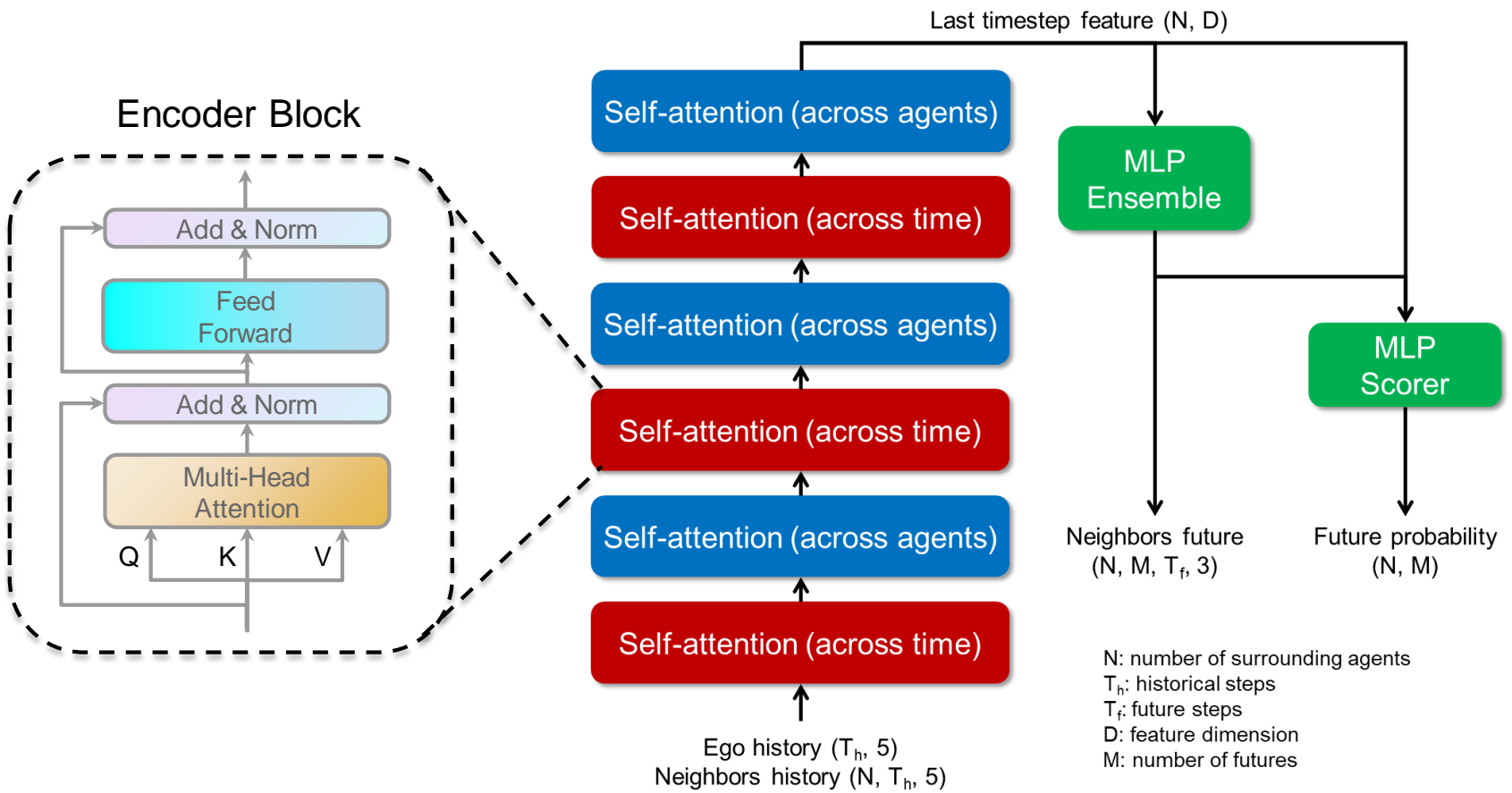
Framework
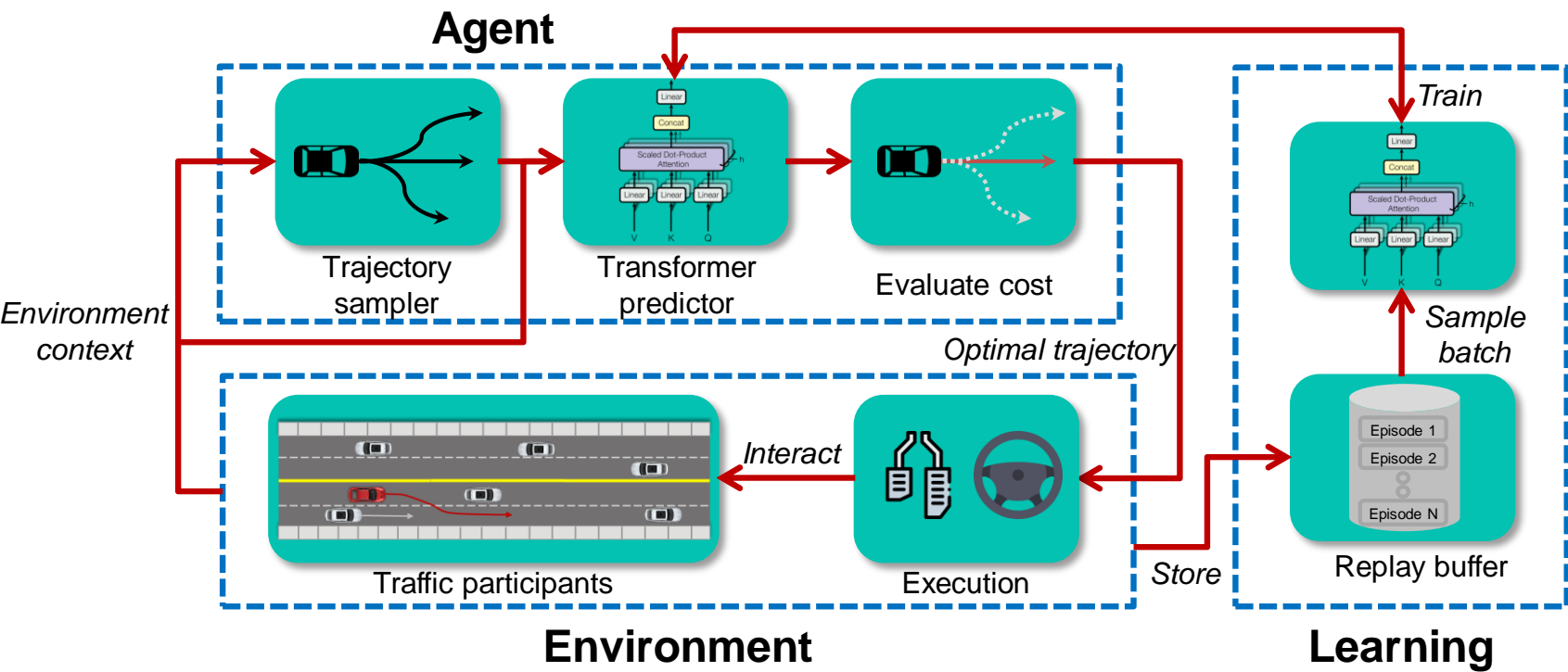
- Planner: trajectory generation ⇨ evaluation ⇨ execution
- Predictor: multi-agent multi-modal future trajectories of interacting agents

Predictor

Agent history trajectories   Trajectory Encoding   Spatial-temporal Space

Temporal Encoder   Spatial Encoder

Yuan, Ye, Xinshuo Weng, Yanglan Ou, and Kris M. Kitani. "Agentformer: Agent-aware transformers for socio-temporal multi-agent forecasting." In Proceedings of the IEEE/CVF International Conference on Computer Vision, pp. 9813-9823. 2021.
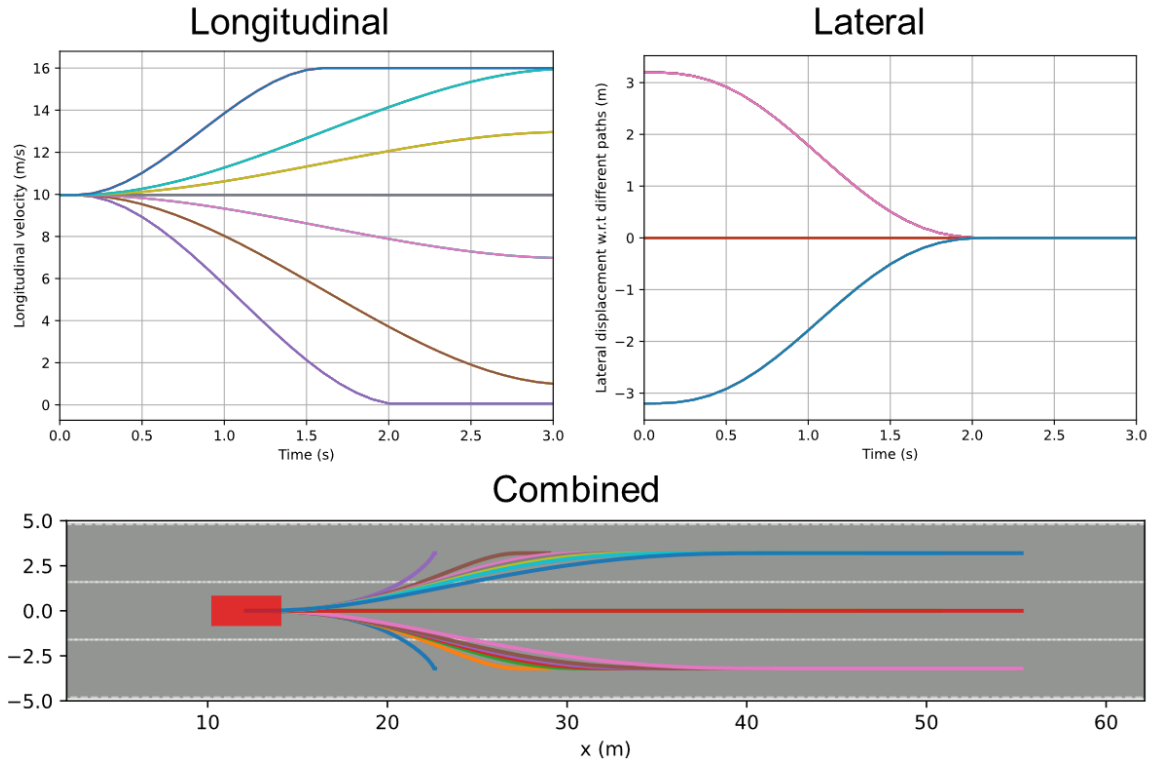
Predictor

Encoder Block

Last timestep feature (N, D)

Self-attention (across agents)

Self-attention (across time)

Self-attention (across agents)

Self-attention (across time)

Self-attention (across agents)

Self-attention (across time)

Add & Norm

Feed Forward

Add & Norm

Multi-Head Attention

Q   K   V

MLP Ensemble

MLP Scorer

Ego history (T_h, 5)
Neighbors history (N, T_h, 5)

Neighbors future
(N, M, T_f, 3)

Future probability
(N, M)

N: number of surrounding agents
T_h: historical steps
T_f: future steps
D: feature dimension
M: number of futures

Planner

❖ Trajectory Generation

1) Get available paths from the observation
2) Generate speed profiles along the longitudinal direction in Frenet space
3) Generate displacement profiles along the lateral direction in Frenet space
4) Combine longitudinal and lateral coordinates in Frenet space and translate back to Cartesian space

Planner

❖ Planning Setting

Planning/prediction horizon T_h	30 steps (3 seconds)
Observation horizon T_f	11 steps (1.1 seconds)
Number of surrounding vehicles N	5
Number of multi-modal future trajectories M	3

❖ Trajectory Evaluation

Cost function	**Linear** combination of features $c(\tau) = -\sum_i \theta_i f_{i,\tau}$
Features	**Goal** (Distance to goal, speed), **Comfort** (jerk, lateral acceleration), **Safety** (distance to the nearest obstacle, time-to-collision, collision)
Collision checking	Check if a generated trajectory of the ego vehicle overlaps with the **most-likely** trajectory of each surrounding vehicle
Emergency	**Decelerate to stop** at max capacity if all generated trajectories are to collide with other vehicles

Training

❖ Sample from replay buffer/offline dataset

Sample an episode   Sample a timestep
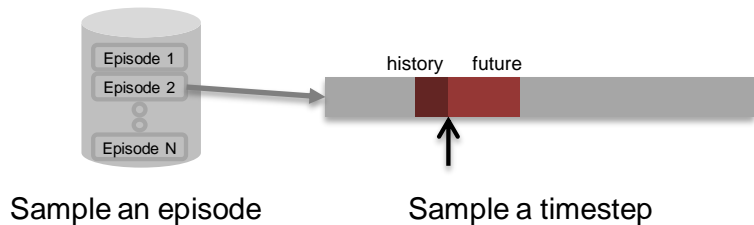
❖ Loss function

$$L_= L_{reg} + \lambda L_{cls}$$

Regression

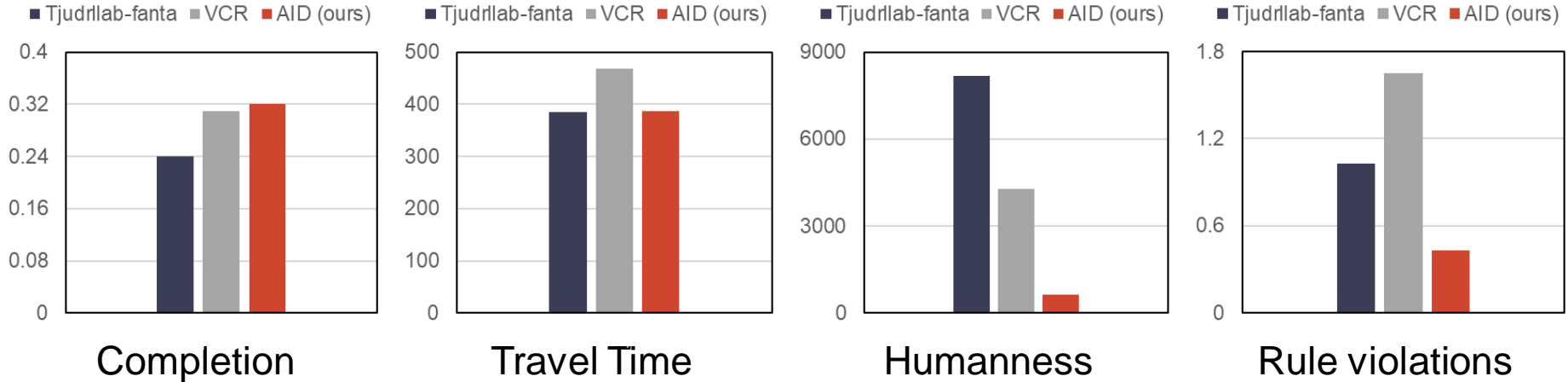$$L_{reg} = \frac{1}{NT_f} \sum_{i=1}^{N} \sum_{t=1}^{T_f} L_{SL1}(\boldsymbol{p}_{i,t}^{*}, \boldsymbol{p}_{i,t}^{gt})$$

$$\boldsymbol{p}_i^{*} = \arg\min_{j \in [1,M]} \frac{1}{T_f} \sum_{t=1}^{T_f} d\left(\boldsymbol{p}_{i,t}^{j}, \boldsymbol{p}_{i,t}^{gt}\right)$$

Classification

$$L_{cls} = \frac{1}{N} \sum_{i=1}^{N} L_{CE}\left(p_i^{*}, I(*)\right)$$

Jiao, Ruochen, Xiangguo Liu, Bowen Zheng, Dave Liang, and Qi Zhu. "TAE: A Semi-supervised Controllable Behavior-aware Trajectory Generator and Predictor." arXiv preprint (2022).

Results
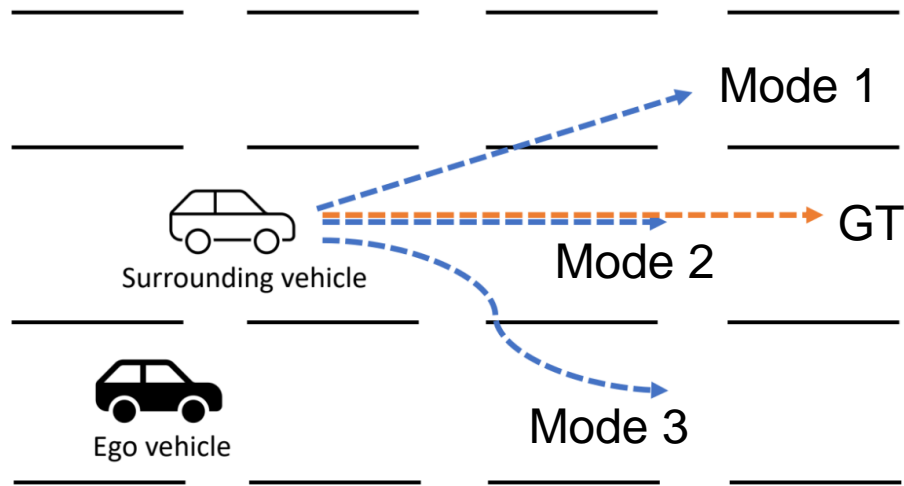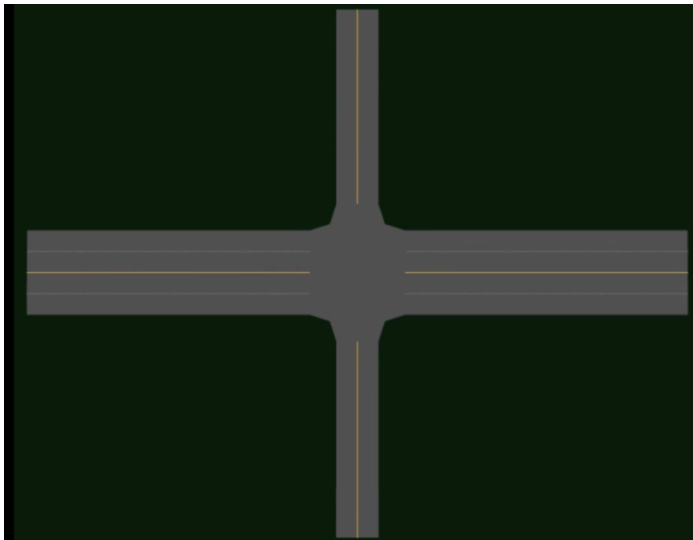

Completion   Travel Time   Humanness   Rule violations

- **Pros**: significantly better humanness and lower rule violations
- **Cons**: lower completion because the planner requires more complete information

Visualization

Intersection/1_to_2lane_left_turn_c

Merge/3lane_single_agent

Thank you for your time!
Q&A