A Comparison of Imitation Learning Pipelines for Autonomous Driving on the Effect of Change in Ego-vehicle

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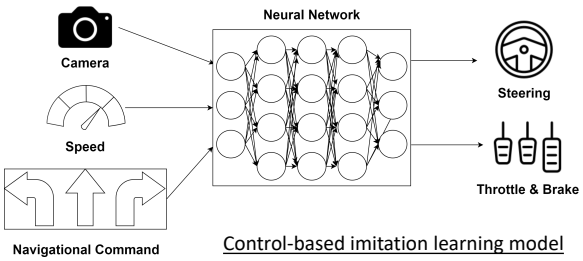
Background

Imitation learning (IL) is the one of the most widely used approaches in autonomous driving. There are two popular imitation learning pipelines:

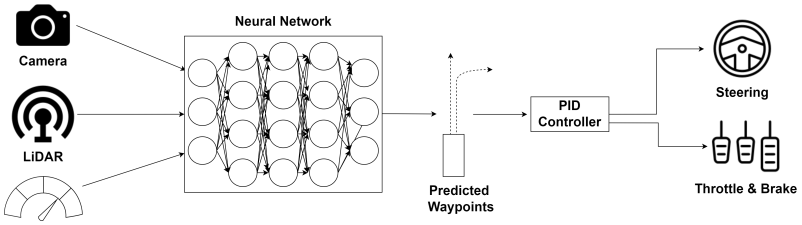
1. **Control-based IL model**: model predicts vehicle controls directly, and
2. **Waypoint-based IL model**: model predicts a sequence of waypoints or future trajectory, while classical controller such as PID controls the vehicle.

In both cases, the models are usually trained with the data collected using a specific ego-vehicle.

Research questions: How well will these *models scale to different vehicles*? How well will these models perform when deployed on a vehicle different from that used in the collection of the training data?



Control-based imitation learning model



Waypoint-based imitation learning model

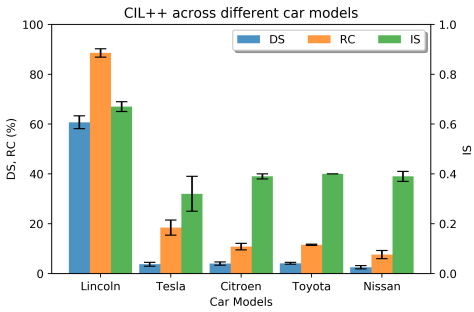
Experiment

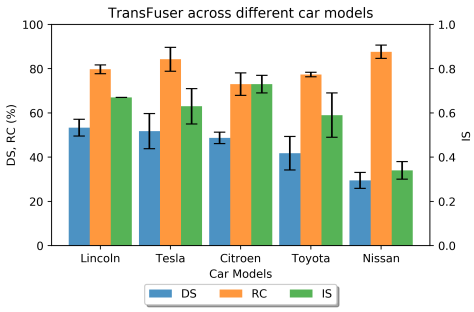
We have chosen two state-of-the-art IL models as the representative models for control-based and waypoint-based models respectively: **CIL++** [1] and **Transfuser** [2]. Their default models were trained on data collected using Lincoln MKZ.

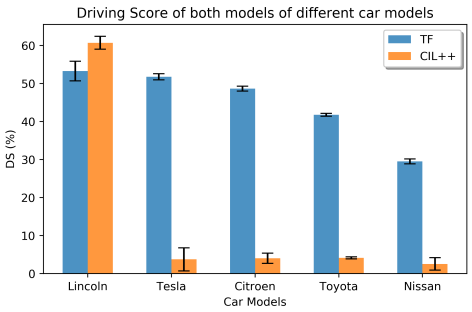
We deployed the default models to five different vehicles in CARLA and evaluated their performance using the CARLA Offline Leaderboard. The *infraction score* (IS), *driving score* (DS) and *route completion* (RC) were used as the performance measures.

Findings

- The performance of *CIL++ was drastically impacted* when deployed on vehicles different from the vehicle used during the training data collection.
- The performance of *Transfuser was less impacted* in comparison to CIL++. Significant decline in performance was observed when the model was deployed to vehicle of significant different physical characteristics from the vehicle used to collect the training data.







Conclusions

- **Waypoint-based IL pipeline is more robust** than the control-based pipeline in learning an autonomous driving agent capable of driving different car models, i.e. scalable to different vehicles.
- **Waypoints provide intermediate representation of the driving task**, without specific to any vehicle.
- **Use classical controller, e.g. PID, to move the vehicle** between waypoints. Tuning of the PID for each specific vehicle can be performed using a classical control approach, or learning-based PID may be developed with small dataset.

[1] Y.Xiao, F.Codevilla, D.Porres, and A.M.Lopez, "Scaling vision-based end-to-end autonomous driving with multi-view attention learning," in IROS 2023.
[2] K.Chitta, A.Prakash, B.Jaeger, Z.Yu, K.Renz, and A.Geiger, "Transfuser: Imitation with transformer-based sensor fusion for autonomous driving," PAMI 2023.