Personalized Trajectory Planning Framework for Autonomous Highway Driving

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Introduction

The field of autonomous driving has made significant progress over the last decades.

- Partially automated
- Fully automated

- Majority of systems designed based on safety
- Not considering individual preferences

Objectives

Development of an autonomous highway driving system with personalized features:

- Ensure safety of the system
- Follow driver's preference at arbitrary maneuvers

Proposed Method

Driver Model

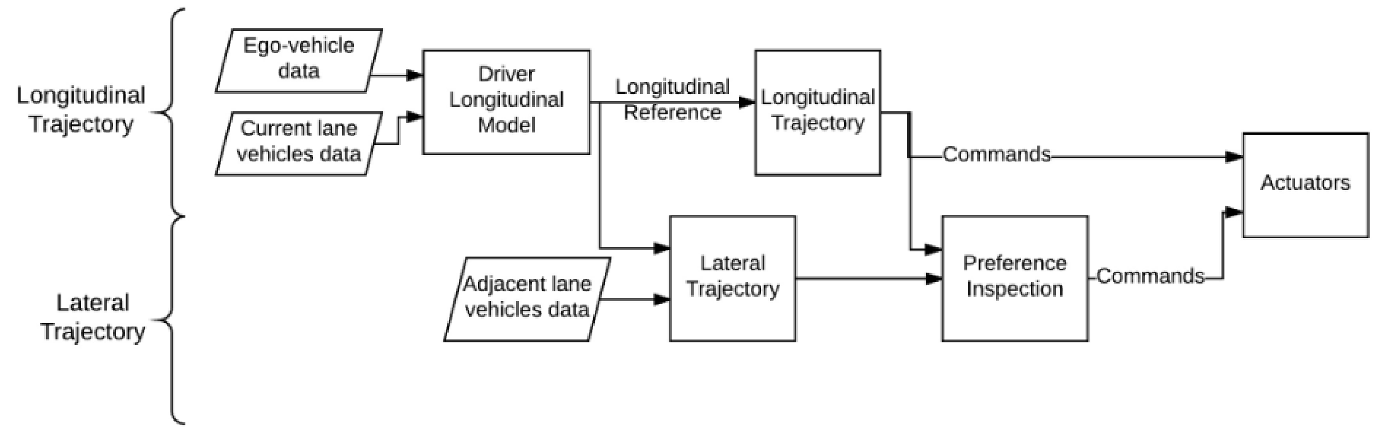
- Model: Random Forest (RF) Regression
- Inputs: Speed + Intervehicle Gap + Relative Speed
- Output: Acceleration
- Data: SHRP2 Naturalistic driving data samples

Trajectory Planning

- A novel model predictive controller (MPC) for tracking varying references.
- Constraints defined for various traffic scenarios.
- Minimizes: Steady State Error + Tracking Error

Decision Maker

The operation modes are chosen based on their compatibility with the driver's preference.

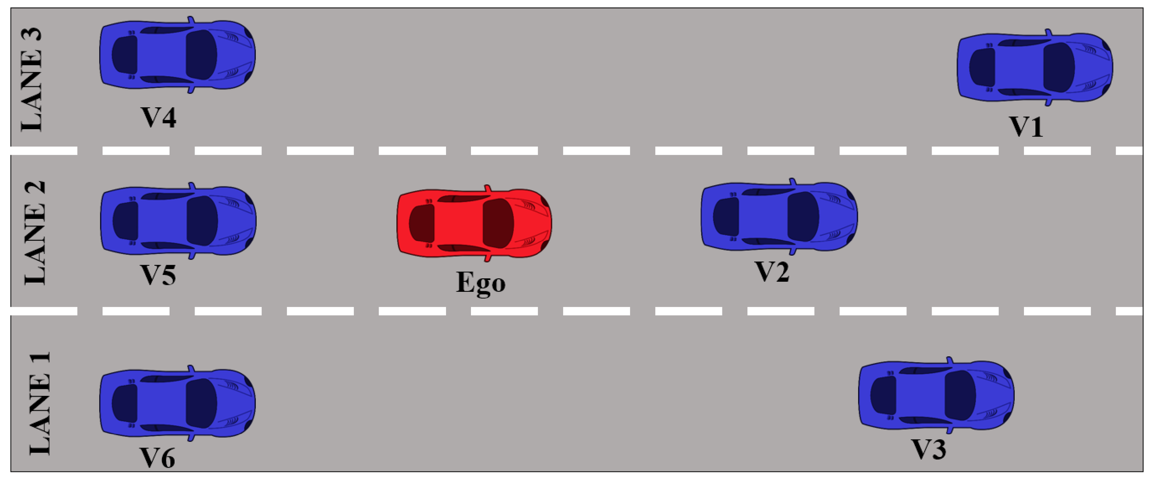


Results

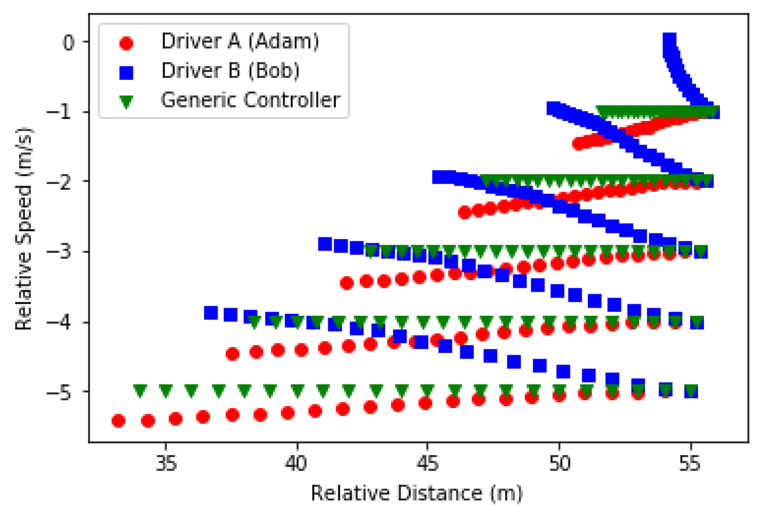
Simulation Environment:

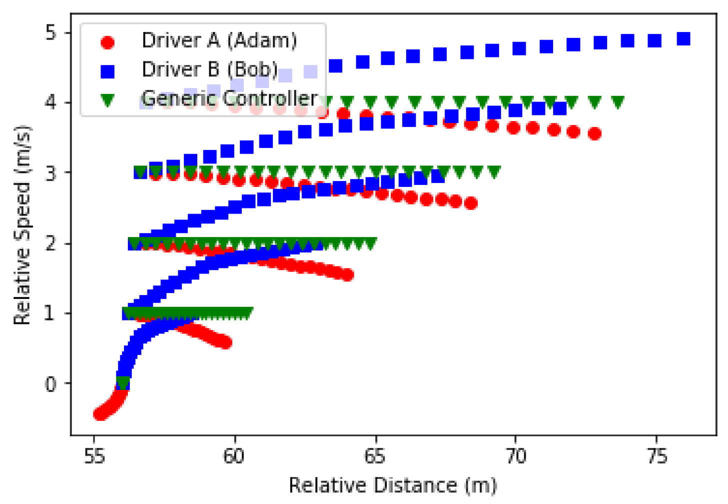
3-lane road with six surrounding vehicles at different positions and speeds

Two drivers preferences are compared: Driver A (Adam) , Driver B (Bob)



Car Following:





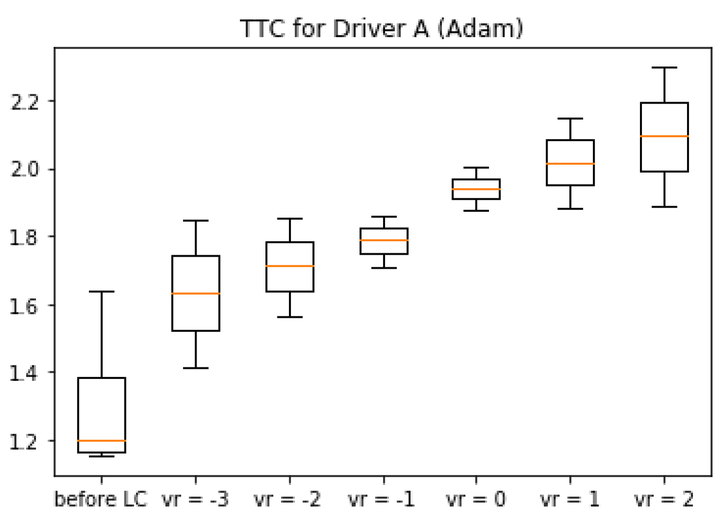
Slower Lead Vehicle:

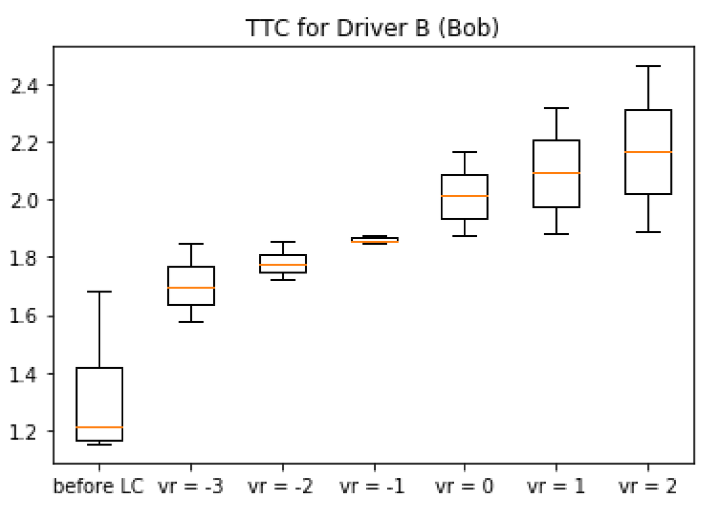
- Bob has a smaller absolute value of relative speed ➔ he prefers to match his speed to the front vehicle
- Adam drives at a relatively higher speed than the front car.

Faster Lead Vehicle:

- Adam prefers to accelerate and drive with a higher velocity, which leads to smaller relative speed
- Bob continues to drive regularly and has a higher relative speed.

Lane Change:





- Adam has a smaller TTC compared to Bob ➔ he can tolerate more risk during lane changes.

Additional Results

Performance Measures of Driver Models;

	$R^2 Score$	RMSE
Driver A Model	0.742	0.113
Driver B Model	0.603	0.176

Comparison of Lane Change Models

	Driver A Data	Driver B Data
Driver A Model	48/50	35/50
Driver B Model	40/50	48/50

Special Cases;

Event 1: Speed limits on lanes: 28, 30, 32 m/s

Event 2: Adjacent lead vehicles drift towards the center lanes

Event 3: V3 suddenly decelerates

Events:	Driver A (Adam)		Driver B (Bob)	
	Action	TTC	Action	TTC
Event 1	LC to L3	2.246 s	LC to L1	2.4579 s
Event 2	Car-following	1.418 s	LC to L1	2.4579 s
Event 3	LC to L3	2.246 s	LC to L3	2.328 s

Conclusion

- Proposed autonomous highway driving system:
- Control system + Data driven driver model

Significance

- Driver preference satisfied + Vehicle safety ensured
- Ability to handle both light and congested traffic situations.
- Ability to detect and handle driving situations where vehicle safety is the priority (specifically with multiple surrounding vehicles)
- Applicable to various driving scenarios (sudden behavior, different speed limits)
- Ability to alternate between path following and car following
- Ability to make a lane change decision, and plan the trajectory

Acknowledgement

This work is partially supported by the US Department of Transportation (USDOT), Research and Innovative Technology Administration (RITA) under University Transportation Center (UTC) Program (DTRT13-G-UTC47. The views and conclusions contained herein are those of the authors and should not be interpreted as necessarily representing the official policies or endorsements, either expressed or implied, of Air Force Research Laboratory and OSD or the U.S. Government.