A Control Mechanism along with an AI-Driven Solution for Safe Autonomous Driving in Roundabouts

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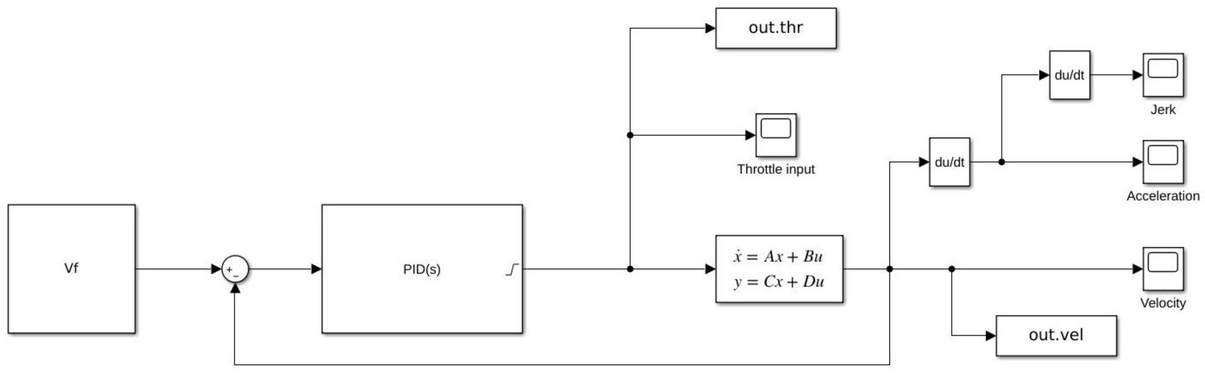
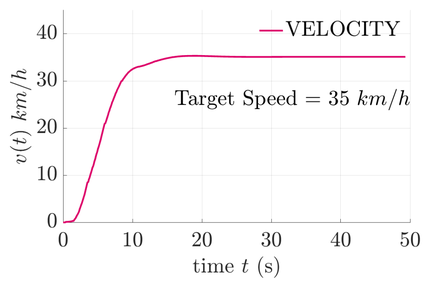
Autonomous Driving and Complexity of Roundabouts

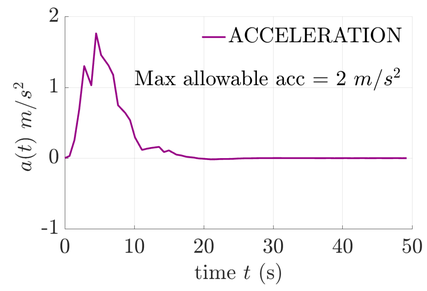
- Autonomous vehicles are well-prepared for lane keeping, acceleration and distance control, lane changing, and even cross sections.
- Current self-driving vehicles still struggle to handle roundabouts safely.
- In case of roundabouts, AI of autonomous cars usually tosses the control of the vehicle to the human driver in the last moment.

Longitudinal Control and Passenger Comfort

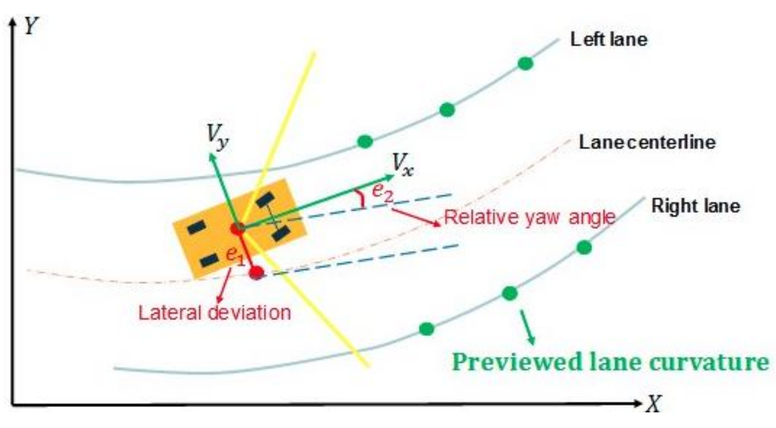
- System Identification
- Transfer Function Interpolation and State-Space Conversion
- A **Tuned PI Controller** in line with Maximum Allowable Acceleration and Jerk
- **Prediction Horizon** of 10 Seconds, **Control Horizon** of 2 Seconds
- Less than **3% Overshoot**

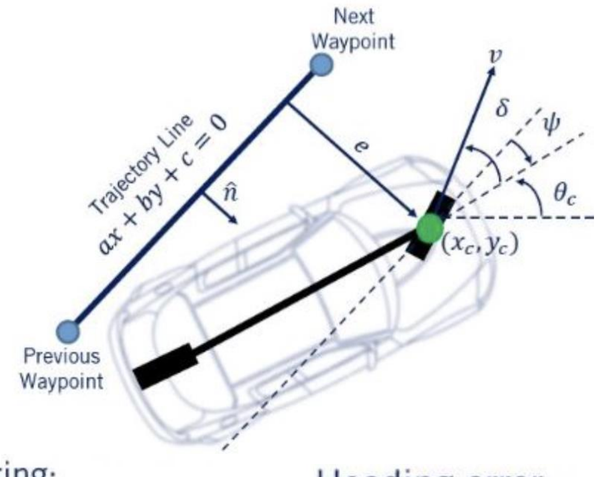






Lateral Control for Waypoint Following





- **Bicycle Model** Estimation and Decoupled Dynamics for Low-Speed Regime
- The Proposed **STANLEY Control Law** by Standford University in DARPA Grand Challenge
- Optimization of Control Gains for Minimizing of the Cross-Track Error

Cross track error:

$$e = \frac{ax_c + by_c + c}{\sqrt{a^2 + b^2}}$$

Cross track steering:

$$\tan^{-1}\left(\frac{ke}{v}\right)$$

Heading error:

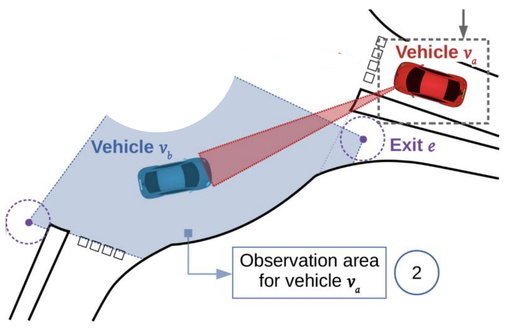
$$\psi = \tan^{-1}\left(\frac{-a}{b}\right) - \theta_c$$

Total steering input:

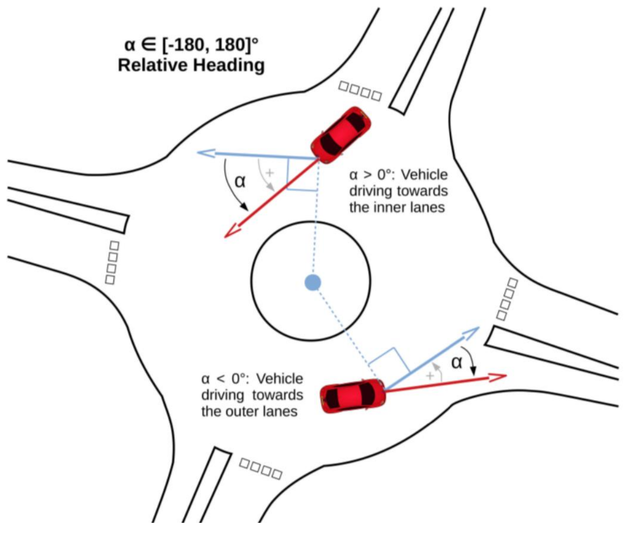
$$\delta = \psi + \tan^{-1}\left(\frac{ke}{v}\right)$$

Artificial Intelligence and Machine Learning for Navigating Roundabouts

- The lateral and longitudinal control need to **avoid conflicts in roundabouts**.
- **AI-based exit probability** estimate the likelihood of such conflict
- Based on **lateral and longitudinal speed** of in-bound vehicles
- The proposed **lateral and longitudinal control** provides a **higher granularity** to train the AI-based exit probability model.



Roundabout Conflict avoidance



AI-based exit probability

Conclusion

- Proposed an **accurate lateral and longitudinal control mechanism** for autonomous vehicles to **safely drive through roundabouts**.
- Roundabout **conflict avoidance** based on **AI**
- Provide **higher precision** in **AI training** for roundabout exit probability