CPS: Collaborative Research: Synergy: Computationally Aware Cyber-Physical Systems

COMPOSITIONAL SYSTEMS LAB

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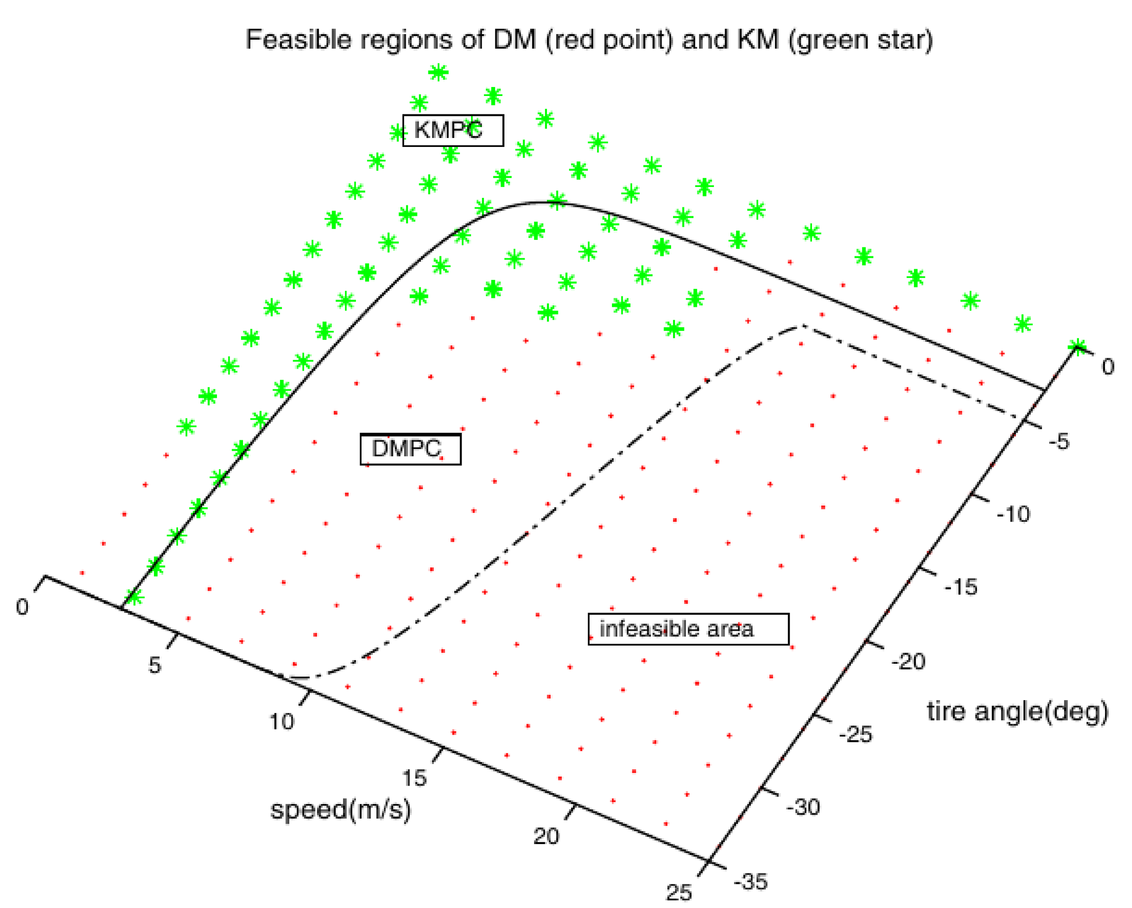
Background and Motivation

The goal of this research is to develop a physics-informed neural network model using real driving data for computationally-aware CPS. The model will be replacing a high-fidelity car simulation used to evaluation the performace of a hybrid model predictive control that switches at runtime between simple model and high-fidelity model. Howver, there was no guarantee that the car simulation model was correct in terms of the vehicle that could be controlled. This research allows us to compare accuracy of hyprid MPC using real vehicle data.

Boundary Between Models

The solid curve is the switching boundary between KMPC and DMPC. The dashed line is the constraint on speed and steering angle, which means any point locating below the dashed line is an infeasible solution.



Nathalie Risso defends her PhD dissertation

Congratulations to **Dr. Maria Nathalie Risso** on the successful defense of her PhD dissertation, titled “**Robust Model Predictive Control for Cyber-Physical Systems**”

References

[1]. Zhang, J. Sprinkle, and R. G. Sanfelice, “Computationally aware control of autonomous vehicles: a hybrid model predictive control approach,”Autonomous Robots, vol. 39, no. 4, pp. 503–517, 2015

[2]. Matthew Nice, Safwan Elmadani, Rahul Bhadani, Matt Bunting, Jonathan Sprinkle, and Dan. Work. 2021. CAN Coach: Vehicular Control through Human Cyber-Physical Systems. 12th ACM/IEEE International Conference on Cyber-Physical Systems (2021).

Main Advancements:

ROS Bridge (CAN-to-ROS)

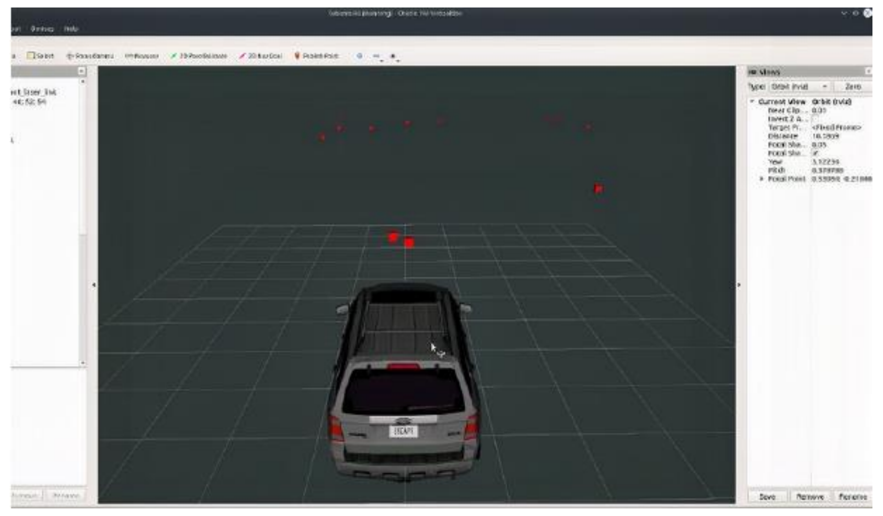
- Transform previously recorded drives into ROS to validate data signals
- Process real-time information.
- Use real-time control on low-computation machine.

Data-driven vehicle analysis:

- Bounding vehicle kinematic/dynamic behavior under similar scenarios.

ROS Bridge: CAN-to-ROS

- A ROS based package for monitoring, recording, and real-time and offline decoding of CAN bus messages.
- The package was evaluated and tested on a Raspberry Pi with real CAN bus data from a Toyota RAV4.



Acknowledgements

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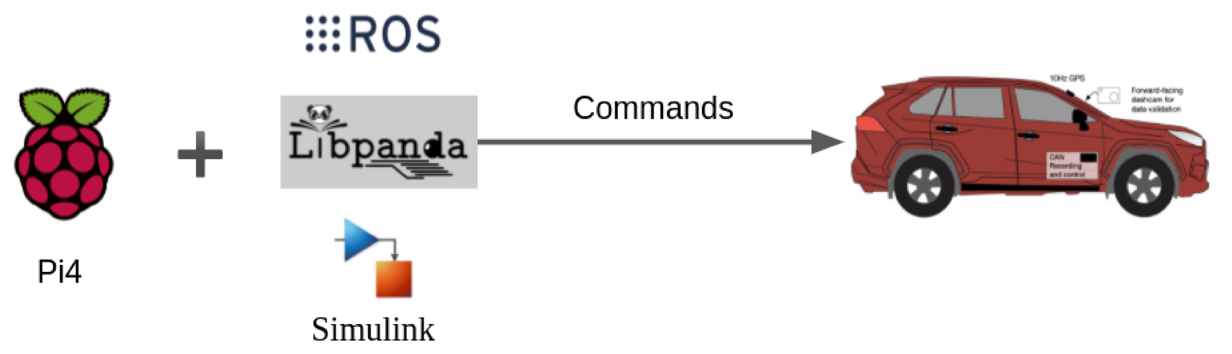
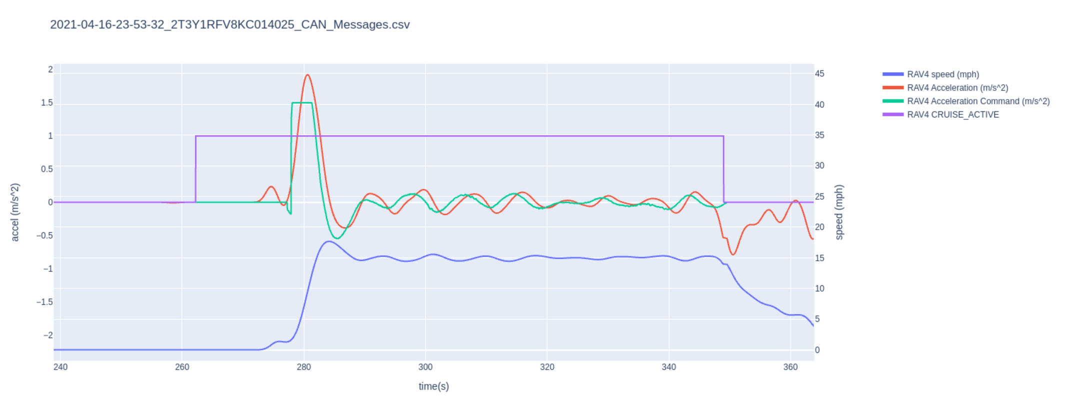
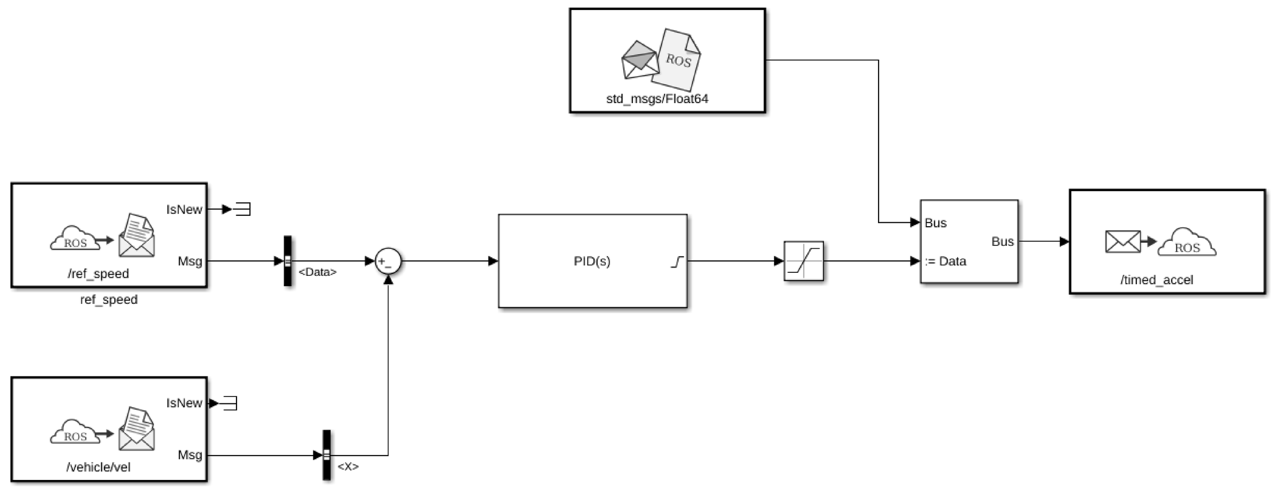
Real-time control on inexpensive computing hardware

- Leveraging ROS framework running on a Raspberry Pi to control a Toyota RAV4.
- CAN-to-ROS package with libpanda wrapper to transform vehicle's data to ROS messages.
- Generating ROS code from a simulink model.





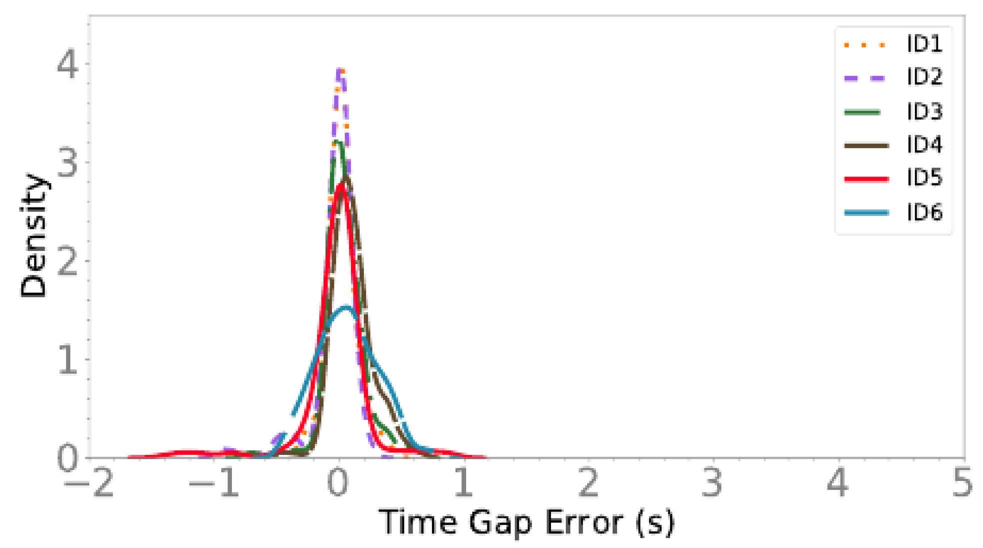


Process real-time information

The can_to_ros packge was used in another work that shows the effectiveness of human-in-the-loop cyber-physical system (HCPS) in improving longitudinal control of an individual vehicle.

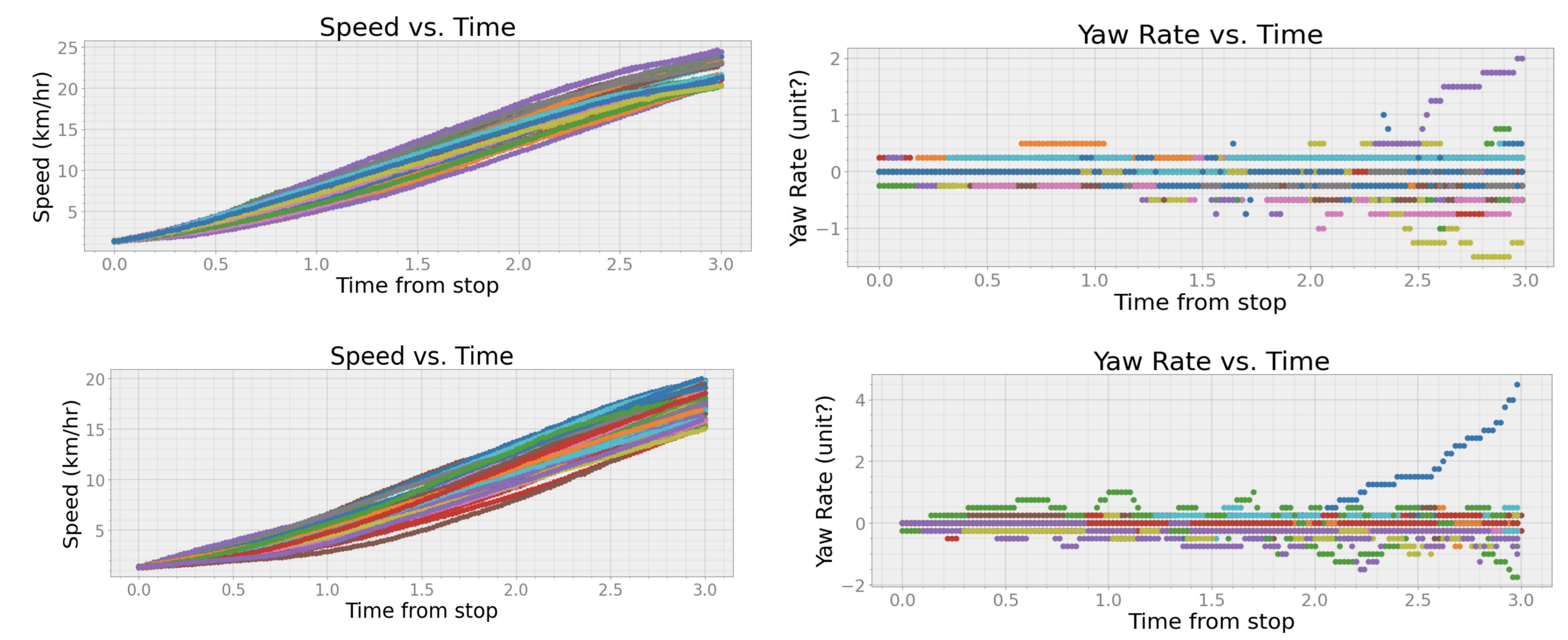
CAN-to-ROS allowed for the smooth transition of critical data from the lower-level CAN data bus to the ROS framework where there is freedom to process, record, and distribute the information reliably and at high frequency.

Having CAN-to-ROS allowed for critical data playback from ROS during testing and development.



Data-driven vehicle analysis

The plots in the first and the second rows have different input ranges.



For a computationally-aware control, the data can be segmented into regions where system identificati on can be compared to kinematic and dynamic models.

Looking at different ranges of inputs provides different ranges of outputs which can lead us toward classifying different behaviors in different regions of the state space---if applied to large number of data inputs