Safety Hybrid Control with Intention Inference for Semi-autonomous Cyber-Physical Transportation Systems

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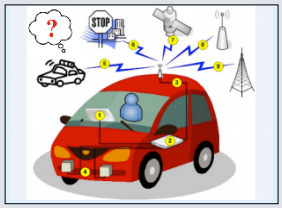
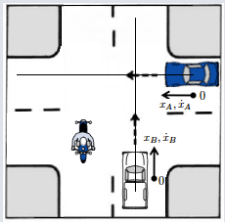


1 Background

In the United States of America alone, over 30,000 people die in road crashes each year and about 40% of those accidents occur at intersections.

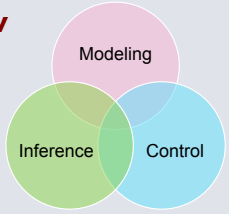


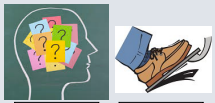
This project involves improving the safety of (semi-) autonomous vehicles at intersections by including the inference of the intention and inputs of other vehicles. Goal: *Development of fundamental theory and computationally efficient algorithms for* ***intention inference*** *and* ***safety hybrid control*** *of cyber-physical transportation systems.*

2 Project Overview

The challenge is three-fold:

- **Modeling**
  - Intention as motion planner at a cognitive level (Model: discrete mode)
  - Decision as motion execution (Model: unknown input)
  - Hidden mode hybrid systems with unknown inputs



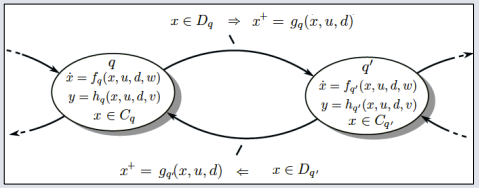


- **Inference**
  - Simultaneous mode, input and state estimation
  - State and input observability
  - Mode identifiability
- **Control**
  - Safety control with mode uncertainties
  - Separation of control and estimation

3 Proposed Methods

3.1

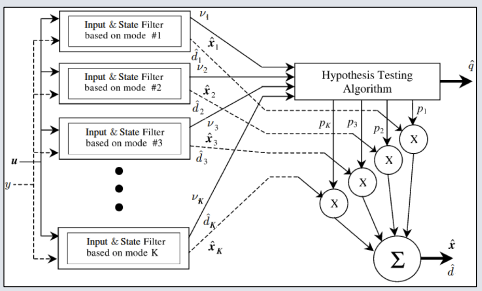
The system is cast in the framework of **hidden mode hybrid system with unknown inputs:**

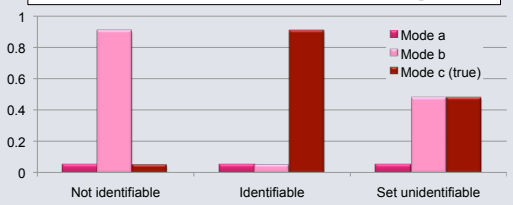


- *x:* continuous state (positions and velocities),
- *q*:={1,2,…N}: discrete state or mode (intention of other vehicles),
- *u* : known control input (input of own vehicle),
- *d:* unknown disturbance input (input of other vehicles),
- *w, v:* process and measurement noises,
- *y:* output measurements.

3.2

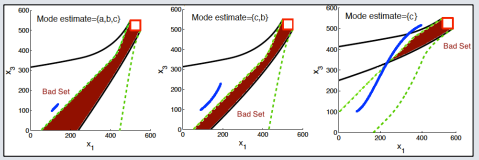
The **multiple model estimation** approach in conjunction with a recent work on **optimal input and state estimation** will be used for simultaneous mode, input and state estimation for **mode identifiable/set identifiable** systems.





3.3

The mode and input estimates are then used to compute the **bad set** (unsafe continuous states), while the state estimate is used for **safety hybrid control,** i.e., to navigate the vehicle away from the bad set.



4 Potential Impact

This project will develop

- an approach for intention inference and safety hybrid control without resorting to overly conservative measures,
- an understanding of issues associated to intention/mode inference such as identifiability and set identifiability,
- general tools for estimation and feedback control of hidden mode hybrid systems.

The developed tools can be applied to other cyber-physical systems such as smart electric grids and healthcare devices where there are uncertainties in operating modes and/or disturbance inputs arising from the interaction with non-communicating systems.

5 References

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Dealing with hidden modes and disturbances in CPS systems? Contact me:
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