MODULE 5 LESSON 1

STATE ESTIMATION IN PRACTICE

Module 5 | Putting It All Together

In this module...

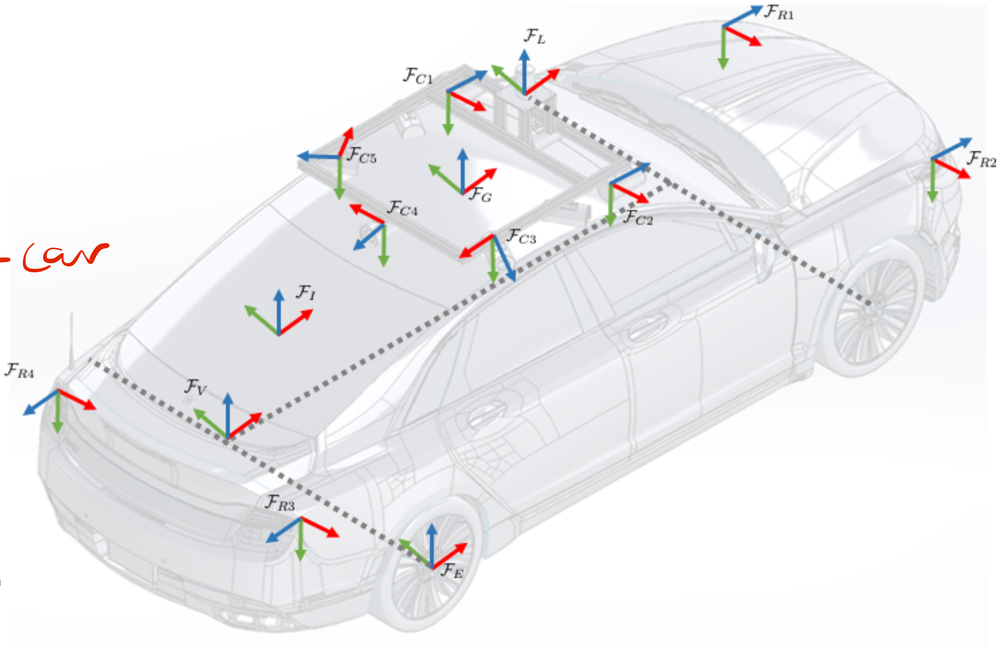
- Sensor fusion
- Calibration
- Sensor failures
- Final project

State Estimation with Multiple Sensors

- Self-driving vehicles rely on data streams from many different sensors (cameras, IMUs, LIDAR, RADAR, GPS, etc.)
- How can we combine information from all these sources?
- We will discuss the *sensor fusion* problem in Lesson 2 and how we can use the EKF to do this

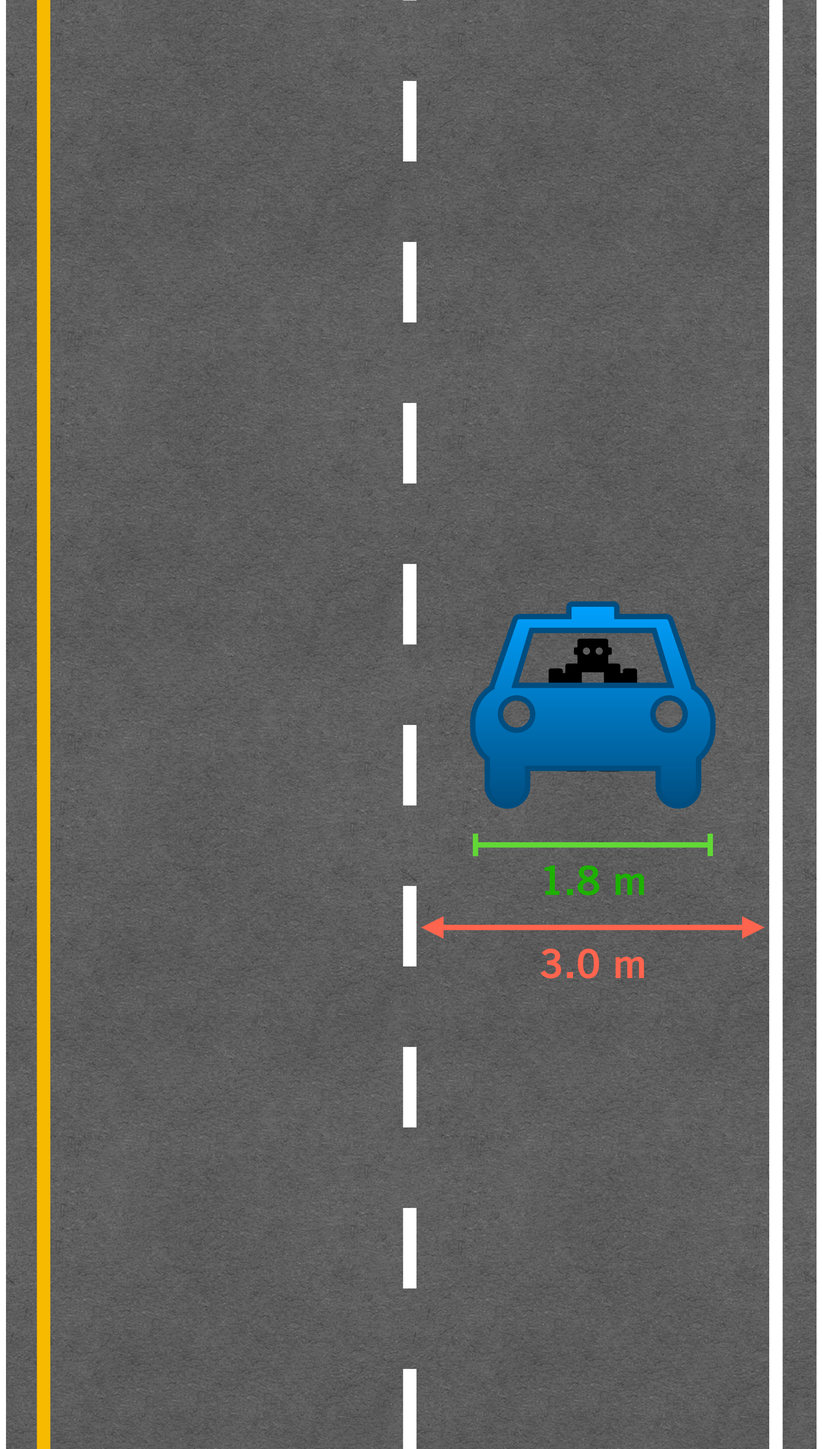
Calibration

- What do we need to know about our sensors and the vehicle to do sensor fusion?
  - *Sensor models,* which may depend on car-specific *parameters* (e.g., wheel radius)
  - *Relative poses* between each sensor pair, so we can combine information in a common reference frame
  - *Time offsets* between sensor polling times, so we combine only synchronized information
- These are all critical forms of *calibration*, which we will discuss in detail in Lesson 3



Accuracy Requirements

- How accurate does the estimator need to be for safe self-driving?
- Typically less than a meter for highway lane keeping
  - Less for driving in dense traffic
- GPS accuracy is 1-5 meters in optimal conditions
  - Need additional sensors!



Speed Requirements

- How fast do we need to update the vehicle state to ensure safe driving?
- How much computation power does the vehicle have on-board?
- How much power can our computing resources consume?

10-30 Hz for self driving

Localization Failures

- How can localization fail?
  - Sensors fail or provide bad data (e.g., GPS in a tunnel)
  - Estimation error (e.g., linearization error in the EKF)
  - Large state uncertainty (e.g., relying on IMU for too long)
- We will discuss strategies for coping with sensor failures in Lesson 4

Our Dynamic World

- Many of the models we use in practice for sensors like LIDAR, RADAR, cameras, etc. assume that the world is static and unchanging
- In reality, the world is always moving and changing
- We need to account for this in our models, or find ways of ignoring objects that don’t fit our assumptions

Summary | State Estimation in Practice

- Practical state estimation typically fuses data from multiple sensors
- Calibration is important for correct sensor fusion
- Estimation algorithms must be designed with speed and accuracy requirements in mind
- Need to be able to cope with localization failures and environmental changes