### Background

- Four-wheel steering (4WS) is an advanced control technique which can improve steering characteristics.
- Compared with traditional two-wheel steering (2WS), 4WS steers the front wheels and rear wheels individually when cornering (according to vehicle motion states: speed, yaw velocity and lateral acceleration).
- 4WS can enhance the handling stability, improve the active safety for a vehicle, and allow a vehicle to turn in a significantly smaller turning radius.

### Objectives

- Design a mechatronic control system to improve handling performance of the automotive vehicle under special steering circumstances and to reduce turning radius.
- Understand basics of vehicle dynamics, 4WS mechatronic control systems, steering kinematics, and Kalman filters.
- Find a function for vehicle trajectory while minimizing turning radius (trajectory based on car’s center of mass).
- Parameterize trajectory curve with vehicle kinematics, steering geometry, desired steering angle, and turning radius.
- Design and test the Kalman filter performance by simulating a U-Turn maneuver to determine the state of a vehicle, and allow a vehicle to turn in a significantly smaller turning radius.

### Abstract

Automotive vehicles call for a range of steering activity: one extreme is highway driving with negligible turning. Another is steering during U-turn maneuvers, which calls for agile turning and a small turning radius to increase vehicle stability. System modeling and simulation are becoming widely used in autonomous vehicle engineering to reduce development time and improve the design and miniaturization of complex systems. This capstone project focuses on steering control system modeling, Kalman filter design, and simulation for optimal vehicle tracking. A 4WS control strategy is established using optimal control theory. The use of 4WS in a vehicle can reduce the turning radius in low-speed steering for more feasible maneuvering. In high-speed steering, 4WS can reduce the yaw rate and lateral movement of a vehicle.

### Kalman Filter Design

- Kalman filter design and vehicle model to estimate position and velocity based on noisy position measurements (GPS sensor). Vehicle can move freely in two-dimensional space without any constraints.
- Design and test Kalman filter performance by simulating a U-Turn with the 4WS control strategy (curved trajectory of 180 degrees).

### Future Work

- Focus on variations in road conditions in order to investigate robustness of proposed control strategy.
- Track a custom 4WS robotic platform and implement closed-loop control for executing a specific maneuver autonomously in GPS denied environment.
- Use petri-net mathematical modeling for safety critical selection of feasible driving maneuvers.

### References