Hands-Free Driving System (HFDS)

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Motivation

Automotive manufacturers are rolling out semi-autonomous features to deliver convenience, efficiency, and enhanced safety features for vehicles. Features can be classified at different levels of automation. Recently, several automotive manufacturers have introduced level 2 or "hands off" driving features. Although this level is considered hands off, drivers must be prepared to resume control of the vehicle.

The objective of this project is to develop a system that is capable of hands-free highway driving. The system will allow drivers to enable a hands-free assisted driving feature which will drive the vehicle in its existing lane without needing to control the steering wheel.

Description

The HFDS system allows a vehicle to automatically steer, accelerate and brake in certain highway conditions. Once activated, the driver can remove their hands from the wheel and is continuously monitored to ensure active engagement with the road. Warnings are issued if 1) the system needs the driver to reclaim control, 2) The driver is deemed distracted.

The driver must first be driving on a highway that has been enabled by the Path Prediction Subsystem. The Driver Assist System validates road conditions, current trajectory, sensor input, and predicted path. If the current trajectory is deemed safe, the user can opt to enter hands-free mode. Once engaged, the user can remove their hands from the steering wheel. The vehicle will enter an adaptive cruise control state and stay within its existing lane for the duration of the session.

When engaged, the Driver Attention System monitors the driver's eyes and head movements to ensure proper engagement with the road. Camera monitoring should work in all lighting conditions. The system can identify if the driver is not properly engaged with the road. If this occurs, various warnings are issued to the driver. A final warning will send vibrations to the driver to reengage. If the system identifies the driver as inactive, the system aborts hands-free mode and if needed, the vehicle will come to a stop.

Besides attentive eyes and head placement, driver interaction is not required. However, the driver can intervene and regain control of the vehicle by either controlling the steering wheel, braking, or throttle.

Safety Constraints

- The system shall detect any single point of failure, then relinquish control to the driver.
- Both hardware and sensor redundancies must be in place to ensure safe operation and provide time for the driver to become reengaged with the vehicle if a problem occurs.

Assumptions

- Lane detection and adaptive cruise control are pre-existing features
- Adequate LiDAR mapping of highways has been captured

Hands-Free driving system (HFDS) consists of the following sub-systems:

1. Driver Assist System: polls the necessary data needed to determine safe conditions, vehicle position, and current trajectory. Ensures safe following distance and initiates braking if necessary. Issues commands to the Vehicle Control Subsystem.

2. Driver Attention System: uses camera(s) to monitor the driver's head movements and eyes to ensure active engagement with the road. If the system determines that the driver's engagement is unsafe, warnings are issued to alert the driver to reengage.

3. Vehicle Control System: accepts input from the Driver Assist System and performs the actions to perform hands-free driving.

4. Human Machine Interface Subsystem: accepts user inputs, displays sensor information and issues/displays various warnings when needed.

5. Path Prediction Subsystem: Calculates the vehicles "blue path" or projected path based on information from the Vehicle Position Subsystem and precision LiDAR mappings.

6. Vehicle Position Subsystem: processes sensor data from the vehicle's cameras, radar, and GPS receiver to validate the vehicle's position in the real-world.

Consider the following scenarios:

Scenario One: System is fully operational with proper road conditions. Demonstrate a user activating the system on a supported highway. Demonstrate how the system issues warnings with the Driver Attention System.

Scenario Two: Consider at least one system failure. For example, the Path Prediction System does not have proper mapping (i.e. construction zones), or the vehicle's radar, camera, or GPS sensors detect a fault. What is the fail-safe state the system should revert to?

Scenario Three: When assisted driving is engaged, demonstrate how the system responds if the driver becomes continuously/permanently disengaged with the road.

Scenario Four: Demonstrate how the system responds when there is a change of control back and forth between the driver and HDFS.

Scenario Five: Consider the security of the system. What measures can be taken to ensure that only authorized commands are sent to the Vehicle Control System.