Design and Implementation of Fault Tolerant Identification and Path Tracking for Autonomous Vehicles

Background

The increased demand for transportation lead to increased interest in autonomous vehicles. Autonomous vehicles are already a reality, however they still have some limitations. Autonomous vehicles has the potential to improve productivity, decrease traffic congestions, decrease the number of accidents, decrease the air pollution as well as decrease the energy consumption.

In order to be able to drive autonomously, the vehicle needs to follow a path/trajectory with minimal error guaranteeing stability and safety. This can only be accomplished by controlling the different systems of the vehicle and guaranteeing a maximum and minimum offset from a given reference path.

The current autonomous vehicles are able to follow the path/trajectory under normal conditions, i.e., when everything is working normally the vehicle behaves as expected. However, in order to ensure safety it is also necessary to ensure the vehicle is able to perform its task when, for example, a steering actuator stops responding, or when a tire blows, or when a motor stops working.

In order to achieve this safety under fault conditions, not only the faults need to be identified and studied, but also new controllers need to be investigated and studied.

Project Description

In these projects you will design and implement new strategies for fault estimation and identification as well as new strategies for path/trajectory tracking. The problem consists in making sure that the vehicle is tracking a path/trajectory reference given by a motion planner under fault conditions which may or may not need to be identified fully.

The project is divided in three parts:

- Design and implementation of a simulation environment where fault can be simulated:
  - Modelling of the vehicle and possible validation with a real vehicle;
- Fault Tolerant Controller:
  - What vehicle model needs to be considered for a specific type of fault?
  - Could a simple model be enough?
  - What type of controller?
- Online fault identification:
  - What needs to be identified?
  - How can the vehicle states be predicted well enough to be accounted by the controller?
  - What can we estimate?

This project can cover two master thesis students, where both collaborate on the vehicle modelling and then one focus more on the online estimation and fault identification and the second focuses more on the controller design.

The project will start by investigating what is currently implemented and available on the Research Concept Vehicles (see Figure 1). These vehicles are designed and developed at KTH at the ITRL-Integrated Transport Research Lab. They are fully equipped with sensors, computers, and actuators, allowing for vehicle automation.

Figure 1 - Research Concept Vehicles

Controller/Fault Handling –

- Formulate the control problems; what faults should be handled?
- Propose a control method to solve the control problem?
- If your control is model-based, what type of model is required? Is a four-wheel model needed or is a two-wheel bicycle model enough?
- Evaluate the controller under normal conditions.
- Evaluate the controller under fault conditions. Investigate the performance and impact of inaccuracies and delays in the fault estimation.

Estimation/Fault Identification –

- Determine what faults need to be identified and what vehicle states need to be estimated.
- Design state estimation and fault identification algorithms.
- Evaluate under normal conditions. How is the estimation affected when we lose some sensors?
- Evaluate the estimation when there is a fault. How well are faults detected and identified? Can more than one fault be handled at the same time?

The implementation will be done using ROS and Python/C++ and you may have to interact with low-level controllers implemented in Matlab/Simulink. At the end of the project all code should be in a good enough state to be used by other engineers and students.

The projects will be developed in close collaboration with other master students, research engineers, PhD students, and Professors.

Deliverables

1. Literature review;
2. Scenario design and formulation;
3. Problem formulation;
4. Implementation;
5. Simulation results;
6. Experimental tests and results;

Depending on the approach taken different deliverables might be needed, for example, data collection.

Details

Number of students: 1 or 2

Start date for the project: January 2021

Estimated duration: 20 weeks

Location: Integrated Transport Research Lab, Division of Decision and Control Systems

Qualifications

Master student with a background in control systems. Knowledge in system identification and vehicle dynamics is not a requirement but it will be valued.

Basic understanding and knowledge of ROS is a requirement. Knowledge of at least one Python/C++ is a requirement.

Contact

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Application

Application should include a CV and a certificate of studies, including courses attended and obtained grades when applicable. Send the application to: Gonçalo, gpcp@kth.se