Vehicle Dynamics modelling of an autonomous electric race car

We are looking for motivated master students Engineering Technology

Project description:

Formula Electric Belgium (**FEB**) is a team of highly motivated engineering students that build an electric formula student race car. Just like Formula 1 the team builds a brand-new car each year to compete in multiple international competitions during the race season. Formula Student is the largest international engineering and design competition in the world. The competition is characterized by combustion vehicles, electric vehicles and since recently also autonomous vehicles. Formula Electric Belgium strives towards innovations and the raw performance of technologies. It is for this reason that the team will focus on the autonomous/electric race cars. Research and development applications will be made by postgraduate students in collaboration with thesis students from the KU Leuven and bachelor students from Thomas More.

Thesis description:

An autonomous software is composed of three algorithms: **Track Landmarks Detection**, **Car Localization and Landmarks Mapping**, and **Car Control**. The first two blocks perform a sensor fusion to simultaneously localize the car on the track and map the track landmarks. The Car control block aims to simultaneously keep the car within the track limits and maximizing the speed.

This year, we developed a **Model Predictive Contouring Control** to perform the Car control. Based on a **mathematical vehicle dynamics model**, this optimization problem takes several constraints (such as the track limits), computes the optimal trajectory that full-fill the two objectives, and outputs the car commands (Steering angle, Throttle, Brake).

Based on an accurate tracking of the car and track landmarks, the Car control algorithm is the area where you can improve your lap time. The key to this performance research is the understanding of the car dynamics behaviour. However, the MPCC mathematical definition requires a linearization of the car motion model, which limits the complexity of the model and therefore, increases the difference with the real motion. This year, we used a kinematic bicycle model that is valid under the low-speed assumption. A **dynamic model** of the car including the **weight transfer** and **tire slip** would allow us to drive at higher speed. Moreover, previous year, our Powertrain and Vehicle Dynamics departments have made strong breakthrough to develop **Energy regeneration at braking** and **Torque Vectoring**. Implementing these technologies on our autonomous car would improve the intrinsic performances of the car. On the other hand, these technologies require researches to mathematically model it.

Thesis objective:

This thesis aims to develop several models of the vehicle dynamics that will be used in the Car control algorithm. These models will be obtained by both mathematical modelling and data fitting. Moreover, this work will include researches to the linearize the models.

Here is a list of motion behaviour/technologies to investigate:

- Weight transfer
- Tire slip
- Ackerman steering
- Energy regeneration at braking
- Torque Vectoring

These models will be validated by a comparison with tests in real conditions.

Are you interested? Please send your resume with accompanying motivation to:
recruitment@formulaelectric.be
Diestsesteenweg 692, 3010 Kessel-Lo

Profile:

- Interested in Vehicle Dynamics and Autonomous Electric Race car
- Creative/Innovative
- Teamplayer
- C++, matlab, python

What do you gain?

- A unique engineering– and team experience where hard work and team atmosphere are central.
- Work with innovative technologies in a realistic environment/application.
- Create added value for your curriculum and the team

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