Volvo Cars PhD Program
ACM – Autonomous Corner Module

Participants
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Research Question
If tyre forces can be controlled more freely, there will be a new range of possible functions and vehicle behaviour, that can not be solved with the conventional chassis. For normal driving conditions, chassis components for propulsion and steering can be used differently, and still, maintain identical vehicle behaviour.

This project seeks to investigate how this range of functions are related to the tyre force generation, and in turn, bring more knowledge into different chassis concepts supporting the tyre force generation. These chassis concepts involve components to generate propulsion torque and lateral tyre forces independently at each wheel.

Project Background
In general, components in modern chassis design can rarely be reused in the development process of new vehicle platforms. This is due to the implementation of functions involving great amounts of hardware. Therefore, new vehicle dynamic functions can involve a great deal of redesign work, even for small modifications. As a result, there has been increasing interest in new chassis solutions where attributes are determined by software implementations. Furthermore, there has been an increasing interest in new functions that cannot be developed using the conventional chassis. Chassis design is also becoming more technically complex due to the fact that the conventional chassis has many constraints. As a result, there have been many studies about designing and controlling a chassis with limited degree of freedom. However, little attention has been devoted to chassis with many degrees of freedom as concerns geometry and kinematics where tyre forces can be freely controlled.

Given this situation, there is considerable interest in a novel chassis design where functions are mainly software-implemented, and tyre forces are allowed to be freely distributed.

One chassis solution that is a vital contribution to these demands, the autonomous corner module (ACM), was invented at Volvo Car Corporation (VCC) in 1998. The name "autonomous" indicates that wheel forces and kinematics are individually controlled supporting a common task.

Approach
Figure 1 shows one method to evaluate chassis, where tyre forces are allowed to be freely controlled. Using this method, tyre forces can be optimally allocated, in order to satisfy cost functions and limitations. Examples of cost function are remuneration to low energy consumption, low tyre wear and exploitation of adhesion potential. The limitations arise from adhesion limitation present in the tyre contact patch (Figure 2) and limitation in actuators.

The vehicle dynamics can be evaluated exploiting the principle of force allocation and closed-loop path control (Figure 3).

One important objective is to evaluate the approach when using realistic actuators (rather than deal with ideal actuators), that can be developed in vehicles of today. Consequently, large effort is put into computer simulation models of actuators, such as electrical in-wheel motors, steering actuators and active suspension.

The trend towards better access to electrical energy buffers and converters along with local generation of tyre forces (e.g. electrical in-wheel motors) bring new problems that are not present in the vehicle architecture for conventional vehicles. One example of this is electrical faults arising in power electronics, which represent a hazardous event. As a consequence, chassis that allow tyre forces to be individually controlled has a definite need of an inherent capacity to handle fault and disturbances in order to ensure satisfactory dynamic behaviour of the vehicle in all driving situations.

Measurements
Model

Project start Lic Project finish
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