Volvo Group Trucks Technology

Master Thesis proposal:

Roll stability control of autonomous truck combination

Truck combinations are in general sensitive to high levels of lateral acceleration as they are prone to roll over. This is mostly due to a relatively high center of gravity, but also to dynamical effects that can build up when multiple trailers are connected. When these vehicles become autonomous it is of course of extreme importance to perform motion control so that the roll stability can be guaranteed. This can basically be achieved in two ways: Firstly as a proactive implementation that is developed to limit the allowed region of lateral acceleration, and secondly as a reactive implementation that is responding if there exist indications of an imminent roll over anyway, see Fig. 1. The thesis will cover both the proactive and the reactive design.

Proactive Roll Stability Design
Roll stability should be considered already when planning a path. A path is a set of reference coordinates and velocities in front of the vehicle. Your task is to develop a set of constrains that should be fulfilled when planning a path in order to guarantee roll stability of the vehicle combination. You should also demonstrate that it is possible to incorporate these constrains when planning a path in practice. It is important to capture both static roll stability as well as other dynamical effects that can cause roll over, for more details see [1].

Proactive roll stability should also be developed for path following, i.e. constrains should also be developed and applied when trying to follow the planned path. A path follower is typically outputting a desired level of acceleration, see Fig. 1. It is therefore rather straightforward to limit this output. Yet, it is again important to set these limits on the background of both dynamical and static roll effects. A very important parameter for roll dynamics is the center of gravity height. This parameter can be estimated, however the uncertainty of such an estimate is most often very high [5,6]. This uncertainty must be taken care of in your design.

Reactive Roll Stability Design
After path control comes the step called Motion Control. The objective of Motion Controller is to coordinate different motion actuators, such as brakes and steering, to achieve both longitudinal and lateral acceleration as desired by the Path Controller. Here you will be working with a method called Control Allocation. Several previous Msc. Thesis projects have been run at Volvo on this topic, e.g. [2-4]. Control Allocation is a model based approach for motion control. It uses a model of the effect that each and every actuator has on the motion of the vehicle. It can also handle constrains, such as tyre road friction and actuator rate constrains etc. The final formulation is an optimization problem that can be solved in real time in order to achieve coordination between the different motion actuators.

Previous attempts to perform roll stability control by means of Control Allocation have only considered the linear region of the tyres (slip up to ~0.2). Yet is known that many other existing roll stability approaches make use of the nonlinear region of the tyres (steering forces are lowered by locking up the wheels by using the brakes), see Fig. 2. Your task will be to investigate how the nonlinear region can be included in the Control Allocation formulation to achieve reactive roll stability.

Thesis Objectives
The objectives of this master thesis are:
1. Develop a suitable set of constrains for performing path planning and path following, so that roll stability is guaranteed when assuming a realistic understanding of important vehicle properties.
2. Develop the concept of Control Allocation so that a reactive roll stability mechanism can be incorporated. Here it is important to make use of the non-linear regions of the tyre force curves if this proves important.

**Prerequisites**
The thesis work will include control theory and real time optimization. The work will be carried out at Volvo Group Trucks Technology. The thesis is recommended for one or two students with control analysis profile with good mathematical skills. Thesis start: Jan 2018.

If you find this proposal interesting send your application with CV and grades to: jonas.fredriksson@chalmers.se

**Contact persons:**
Jonas Fredriksson – Chalmers S2
tel: 031-772 13 59,
mail: jonas.fredriksson@chalmers.se

Leo Laine – Volvo GTT
tel: +46 31 323 5311
mail: leo.laine@volvo.com

Kristoffer Tagesson – Volvo GTT
Tel:+46 76 553 4867
Mail: kristoffer.tagesson@volvo.com

**References:**


