Volvo Car Corporation

Master thesis proposal (Dec. 2013)

Brake Control Module (BCM) Tuning Employing Computer Aided Engineering (CAE)

* Location	* Category
Göteborg	**96560: Vehicle dynamics and control**

Description of thesis work

Abstract

Tuning the BCM, and more specifically the antilock braking system (ABS) and the dynamic stability and traction control (DSTC) subsystems, normally involves physical vehicle testing; a time consuming and costly procedure. This procedure is normally performed in an early phase in the development process where only prototype vehicles are available. It is envisioned that in an effort to reduce prototype vehicles, the BCM tuning in future vehicles will be achieved using CAE.

Background

The BCM tuning will have to satisfy independent organizations, e.g. EuroNCAP, which perform safety rating and publish reports on new cars based on a variety of tests. EuroNCAP assesses the DSTC by performing a series of tests in which steering and yaw behaviour can be simultaneously evaluated [1]. These tests are based on an actual double-lane change (DLC) manoeuvre. The DSTC and the vehicle's handling are also rated subjectively [2] using tests such as ISO 3888 DLC. Although the aforementioned methods are often used for handling rating and consecutive tuning, they are sometimes characterized unsuitable for objective assessment of the vehicle's performance because the driver is involved in the control loop [3]. Objectivity can be ensured by examining solely the vehicle's behaviour. Substituting test drivers by a controller which would generate the optimal steering inputs for achieving maximum entry speed would enable the definition of an objective performance metric [4] and a tool to assess the vehicle's handling, early in the development process. A tool for generating the optimal steering control input for maximizing the vehicle's entry speed has already been developed at Volvo Cars [5] (c.f. Fig. 1). CAE tuning of the BCM, besides reducing cost and lead time, will also facilitate objective assessment of the car's safety and numerically optimized tuning sets.

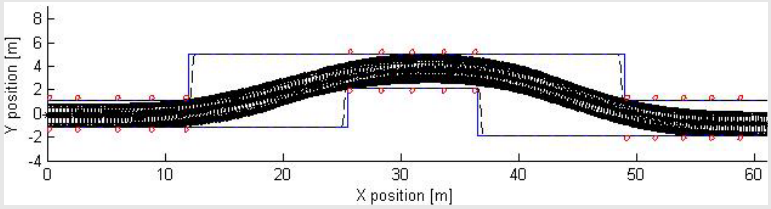

Fig. 1. General vehicle trail. The thickness of the outer black lines is proportional to the vehicle slip angle [5].

Scope

This research thesis aims to develop the method for BCM tuning employing CAE and numerical optimization techniques.

Thesis overview

- Literature study:
  - Control theory for dynamical systems (optimal, robust).
  - Existing control methods for vehicle optimal steering control [5].
  - Vehicle dynamics and vehicle mechatronics.
  - ABS, DSTC and its functionalities.
- Goals/ milestone definition:
  - A suitable vehicle dynamics model (VDM) should be exported from multi-body simulation (MBS) software and should be interfaced with a brake model and powertrain model which will eventually interface with the BCM. The results from the simulation will be analysed and the BCM's performance will be evaluated accordingly against its validity.
  - A method for performing qualitative analysis results should be established together with the VCC engineers, currently responsible for tuning the BCM and in conjunction with the BCM supplier. Method for translating objective metrics from BCM testing into the correct tuning sets utilizing

optimal control techniques.

- Documentation: document the results in a thesis report and make final presentation.

Risks & Limitations

The problem is rather complex; the VDM should be realistic close to the operation range of the ABS and DSTC; the optimization solution may be a global optimum is simulation but not in physical testing.

Prerequisites

- Car enthusiast, interested to further work in the automotive industry. The results can be applied into racing.
- Interested in vehicle dynamics with strong understanding of dynamical systems.
- Background in control systems.
- Highly motivated students for research. The current research thesis has potentials to evolve to a strong tool for Volvo Cars. Upon successful completion of the work, the outcome will be explored to derive scientific publications.

References

[1] Euroncap, "How the ESC is tested," Available: http://www.euroncap.com/Content-Web-Page/bf07c592-4f87-404e-bb06-56f77faee5a2/esc.aspx

[2] G.J., Forkenbrock , W.R. Garrott, M.H., B.C. O'Harra, "An Experimental Examination of J-Turn and Fishhook Maneuvers That May Induce On-Road, Untripped, Light Vehicle Rollover," *SAE paper*, 2003-01-1009.

[3] J. J. Breuer, "Analysis of Driver-Vehicle-Interaction in an Evasive Manoueuvre - Results of Moose Test Studies," *Proc. of the 16th ESV Conference*, 1998, Paper No: 98-S2-W-35.

[4] D. Katzourakis, C. Droogendijk, D. Abbink, R. Happee, E. Holweg, "Force-feedback driver model for objective assessment of automotive steering systems," *Proc. of the 10th International Symposium on Advanced Vehicle Control, AVEC10*, 2010, pp. 381–386.

[5] S. Angelis, M. Tidlund, M. Lidberg, D. Katzourakis, "Optimal Steering Control Input Generation for Vehicle's Entry speed Maximization in a Double-Lane Change Manoeuvre," to be submitted, Volvo Car Corporation, Göteborg, 2013.

The duration of the thesis work is 20 weeks and the work will be carried out at the Volvo Car Corporation, Göteborg.

Suitable Student background		
Good knowledge of automotive/mechanical engineering.		
Starting date	**Number of students**	
December 2013	1 or 2	
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