Volvo Car Corporation

Master thesis proposal (Dec. 2013)

Steering System Parameterization Employing Computer Aided Engineering (CAE)

* Location	* Category
Göteborg	**96560: Vehicle dynamics and control; statistical methods**

Description of thesis work

Abstract

The parameterization of the steering system normally involves physical vehicle testing and is normally performed in an early phase in the development process where only prototype vehicles are available; a time consuming and costly procedure. It is envisioned that in an effort to reduce prototype vehicles, the steering system parameterization in the future will be achieved using CAE. CAE tuning of the steering system, besides reducing cost and lead time, will also facilitate objective assessment of the car's steering DNA and numerically optimized parameterization sets.

Background

The steering feedback plays a crucial role in the automotive design process. Although the driver–steering wheel interface has to conform to certain rules (e.g. force-feedback torque levels, steering ratio, etc.), the optimal haptic sense is subjective and debatable [1]. The steering system parameterization is therefore of key importance and can reflect the company's steering DNA.

Steering sensitivity and steering torque gradient constitute a subset of important metrics describing on-centre vehicle dynamics response and steering feedback (c.f. Fig. 1). The steering system parameterization would normally have to guarantee that such as the aforementioned metrics fall within a prescribed range and that the vehicle offers a subjectively-rated appropriate steering feedback. Conventional methods for subjective rating are sometimes characterized unsuitable for objective assessment of the vehicle's performance because the driver is involved in the control loop [2].

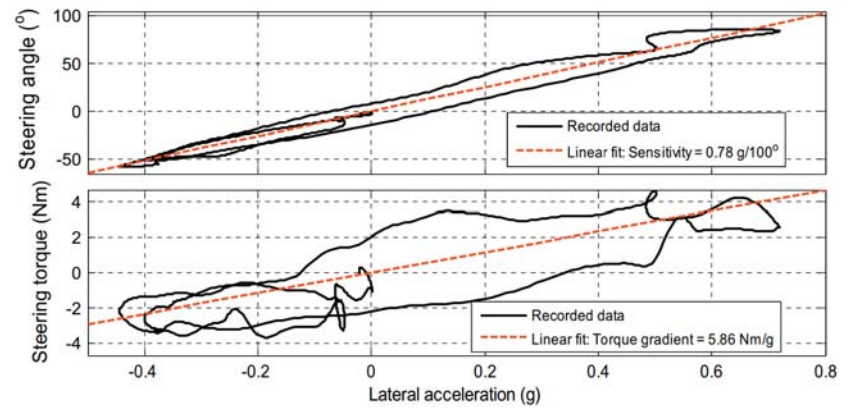

Fig. 1. Hysteresis loops of the steering angle (top) and the steering torque (bottom) versus the lateral acceleration [1].

Scope

This research thesis aims to develop the method for steering system parameterization employing CAE and numerical optimization techniques. The thesis should address:

1) the correlation between the subjective steering system rating and the steering metrics and
2) the numerical optimization of the steering parameters that would enable that the steering metrics fall within a prescribed range and satisfy the subjective rating correlation.

A tool utilizing numerical optimization techniques for generating the optimal steering control input for maximizing the vehicle's entry speed has already been developed at Volvo Cars [3].

Thesis overview

- Literature study:
  - Control theory for dynamical systems (optimal, robust).

- Steering system and its functionalities.
- Statistics: correlation and dependencies.
- Vehicle dynamics and vehicle mechatronics.
- Existing control methods for vehicle optimal steering control [3].

- Goals/ milestone definition:
  - Statistical method for correlating objective steering metrics with subjective rating.
  - A suitable vehicle dynamics model (VDM) should be exported from multi-body simulation (MBS) software and should be interfaced with a steering system model.
  - The results from the simulation will be analysed and the derived steering metrics performance will be evaluated accordingly against its validity.
  - Derivation of the numerical optimization method that will enable steering system parameterization which satisfies that the steering metrics fall within the prescribed range.
- Documentation: document the results in a thesis report and make a final presentation.

Risks & Limitations

The problem is rather complex; the VDM should be realistic enough; the optimization solution may be a global optimum is simulation but not in physical testing. Translating subjective into objective metrics will be challenging.

Prerequisites

- Car enthusiast, interested to further work in the automotive industry.
- 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] D. Katzourakis, J. C. F. de Winter, S. de Groot, R. Happee, "Driving simulator parameterization using double-lane change steering metrics as recorded on five modern cars," *Simulation Modelling Practice and Theory Journal*, vol. 26, pp. 96-112, 2012.

[2] 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.

[3] 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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