Optimized Vehicles based on Customer Usage

A statistical approach for detecting driving events and evaluating their fatigue damage

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Project within ”Fordonsutveckling”

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Content

FFI in short

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

For more information: www.vinnova.se/ffi

1. Executive summary

A key to being able to optimize the weight of the vehicle without risking reliability and durability is to understand the driving conditions as the vehicles are exposed to and how they affect vehicles - especially, it is important to understand the variation in loads due different transport tasks, use, markets, traffic situations and road conditions. In order to do this it is necessary to develop strategies for collecting load information as well as to balance the information from various sources. On 24 Sept 2014 defended Roza Magshood their LIC dissertation, "A statistical approach for detecting driving events and evaluating their fatigue damage". In the thesis, she presents a statistical method with "Hidden Markov Matrix" to describe curves and manoeuvres based on the logged data

2. Background

In vehicle engineering is an important aspect of designing a vehicle with high quality in its components. Therefore, considering the service loads conditions is necessary. In addition, the fatigue design loads need to be assessed. By describing the load environment, the customer usage and the vehicle dynamics, one can define the load condition.
One source of variation in the loads is the driver's behaviour. The driver can affect the load by changing the speed, braking or adapting to the curves. This behaviour can be characterized as driving events. To identify the events we need to use information available for all vehicles by means on CAN (Controller Area Network) bus data.

3. Objective

The overall aim of the project is to develop dimensioning criteria optimized towards customer segments that can be used in the Volvo product development activities for reduced fuel consumption and environmental impact.
Chalmers project means that the expertise built up over many years in applied mathematical statistics used to support industry-related development. In addition, to further develop competence area in the terms and consolidates its position in the absolute forefront internationally

4. Project realization

Volvo's role has been to give the project an industrial application. In addition, Volvo has contributed with data collection and knowledge of the parameters that have been relevant to study.

Chalmers' role was to be responsible for implementation of the project and its scientific level. Chalmers along with SP has assisted with skills in mathematical modelling that takes into account the uncertainties and statistical design of experiments as well as supervision of doctoral student.
Volvo, SP and Chalmers has a long tradition of this approach and it has worked very well in this project

5. Results and deliverables

A clear trend in the development of commercial vehicles is the increased utilization of the vehicles own electrical and control systems for gathering information on the use, so-called On-board logging. Access to hundreds of measurement and control signals from different systems allows detailed evaluation of the actual vehicle use. In this way one can get a very clear picture of the cumulative load history for example, control components, maneuvering, brake systems, axles, drive shafts, etc., for each vehicle, instead of expensive dedicated measurements with strain gauges and external measurement system on a very limited population of vehicles.

The aim of the project is to develop mathematical models to describe and evaluate vehicle loads for different target customers. These mathematical models / descriptions should then be used as a base for on-board logging and as input to simulation and testing, especially in life expectancy, the documents and comfort aspects.
By developing the methodology for systematically improving and refining load data, the project will create conditions for future weight optimization, which in turn brings benefits such as increased capacity, reduced fuel consumption, reduced material usage and less road wear. All these points can be summarized as reduced environmental impact. Even the knowledge of the extreme load cases will increase, which is of fundamental importance for vehicle safety.
The scientific results of the project are reported in Roza Magshood Lic thesis "A statistical approach for detecting driving events and evaluating their fatigue damage". In her thesis, she presents a statistical method with "Hidden Markov Matrix" to describe curves and maneuvers based on the logged data. Two different approaches have been considered in order to estimate the model parameters.
Damage Calculations can be used in design to reduce fuel consumption and environmental impact

6. Dissemination and publications

6.1 Knowledge and results dissemination

Successful development in this area will lead to increased competitiveness of AB Volvo, and ongoing development of skills over many years built up along with the SP and Mathematical Statistics at Chalmers. Overall, this supports the automotive industry's competitiveness and promotes employment in Sweden.

6.2 Publications

R. Maghsood, P. Johannesson, "Detection of the Steering Events based on Vehicle Logging data using Hidden Markov Models", (submitted to International Journal of Vehicle Design).

R. Maghsood, Igor Rychlik, "Estimation of Fatigue Damage of Steering Components using Vehicle Independent Load Model", (submitted to Probabilistic Engineering Mechanics).

R. Maghsood "A Statistical approach for detecting driving events and evaluating their fatigue damage" Tekn Lic, 2014, Chalmers Tekniska Högskola.

7. Conclusions and future research

By enabling optimization of vehicles with regard to the use, the project will result in weight loss, which in turn brings benefits such as increased capacity, reduced fuel consumption, reduced material consumption during production and reduced road wear. All these points can be summarized as reduced environmental impact.

Continued research will be conducted through four activities:

A. Collection of customer data from on-board Logging operations to common customer vehicles and specially instrumented vehicles.

B. Develop statistical theory to balance the information from various sources.

C. Develop logging strategies to effectively be able to implement detection algorithms in embedded systems for on-board logging of events.

D. Mathematical modeling of automotive independent parameters for different customer applications.

8. Participating parties and contact person

Responsible for the project has been Volvo Truck Corporation

Partners Chalmers University of Technology and SP Technical Research Institute