MSc Thesis proposal in Vehicle Dynamics:

A method to span the mission space of vehicle usage based on a set of log files

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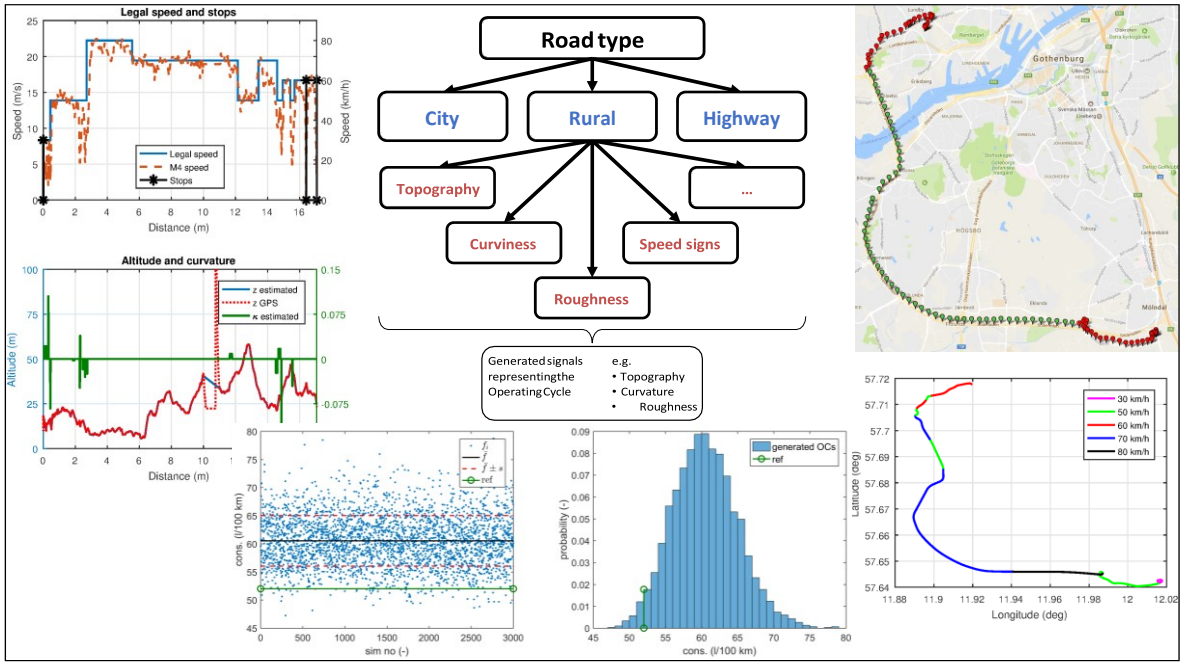
Background

Driving cycles have been the dominating way of describing vehicle use in simulations of transport efficiency, CO_2-emission, and fuel consumption. A conventional driving cycle describes a target speed as a function of time. Recently it has been highlighted that such a description is oversimplified. The exact speed profile of a drive cycle is the outcome a specific vehicle performance. Hence, there is an inherited connection between a specific driveline and the drive cycle. This makes conventional drive cycles less suitable for describing e.g. transport mission independent of the vehicle.

A new description, the operating cycle-format (OC) [1,2], that was suggested earlier this year avoids many of the problems. It includes the essentials of the road, weather, traffic, and mission that are needed to describe the physics of the road-vehicle interaction.



However, being a more realistic and complex description, it renders many of the methods for conventional driving cycles obsolete and new ones are needed. For example, comparing different driving cycles is relatively straight-forward and uses obvious (and some not-so-obvious) measures such as mean speed, duration, mean positive and mean negative acceleration, mean traction force etc., see [3-5]. The OC-format has few such measures and comparing two missions becomes a challenging problem.

A possible approach is to look at each underlying phenomenon as a stochastic process and try to find models that describe the physical properties well [6,7]. The parameters of those models have interesting statistical characteristics and are useful for many things, for example as measures to compare dOCs. In addition, a stochastic model offers the interesting advantage that it can generate new missions, which enables a wealth of theoretical and numerical studies. However, the stochastic description is still an abstract construction with many parameters. If log files of previous missions are available, they can be converted into the dOC format and a statical description sOC can be estimated based on these, see [9].

To further describe the complete usage of a vehicle one needs to find a set of representative log files. This can be based on heuristic arguments such as the frequency of typical missions in the log files, such as in [10]. However, to cover the usage such argument needs to be grounded in both physics and frequency. How this should be done is an open question.

This problem is an active research subject that combines stochastic modelling, data analysis, driver, and vehicle modelling, as well as dynamic simulation that involve all parts. The project at Chalmers is called COVER [8] and involves Volvo GTT, Scania, Volvo Car Group, RISE, VTI and Chalmers.

Problem description

The aim of the thesis project is formulating a metrics to assess a best possible way to find to span the missions by selecting representable log files that can be used in simulations.

Research Question

- How can we assess the span of missions?
- How can we, based on the assessment, choose representative missions through log files?

Deliverables

- A set of algorithms, implement in Matlab that can
    - automatically pick representative log files
    - evaluate how well the picked files span the mission space through a numerical assessment
- A report that describe the methods and illustrate them to a set of examples

Tentative plan

- Define a metric to assess how well a set of log files (and their OC format equivalent) span the entire set of log files. This step is belied to be grounded in physics such as prioritization of parameters of importance from energy perspective and occurrence frequency in the set.
- Make a larger numerical example based on a set of real log files.

Academic subject / pre-requisites:

- Modelling and simulation skills with automotive interest.
- Particularly students from fundamental physics, engineering physics, engineering mathematics, mechatronics/control or mechanical/automotive.
- At least a basic course in stochastic processes.
- Understand the fundamentals of mathematical statistics.

Administrative

- Number of credits: 30 points per student (nominally 20 weeks).
- Starting date: January 2021 or earlier.
- Resources/Stakeholder: Chalmers (the thesis will be strongly connected to the COVER project and the partners within this consortium.).
- Responsible subject/research group at Chalmers:
    - Examiner: Fredrik Bruzelius.
    - Supervisors:
        - Pär Johannesson (RISE & Mathematics Chalmers/GU)
        - Industrial: Rickard Anders (Volvo GTT).
- Application to: Fredrik Bruzelius*, fredrik.bruzelius@chalmers.se, with CV and transcripts.*
- Physical location: Chalmers and possibly also at Volvo GTT

References:

[1] Pettersson, P., Berglund, S., Jacobson, B., Fast, L., Johannesson, P., Santandrea, F., A proposal for an operating cycle description format for road transport missions (2018), European Transport Research Review 10:31, pp 1-19.

[2] Pettersson, P., On numerical descriptions of road transport missions (2017), licentiate thesis, Chalmers Univ. of Tech, Göteborg, Sweden.

[3] Nyberg, P., Evaluation, generation and transformation of driving cycles (2015), PhD-thesis, Linköping University, Linköping, Sweden.

[4] Zaccardi, J.M., Le Berr, F., Analysis and choice of representative drive cycles for light duty vehicles – case study for electric vehicles (2013), Proceedings of the Institution of Mechancial Engineers, Part D: Journal of Automobile Engineering, 227:4, pp. 605-616.

[5] Lee, T., Filipi, Z., Synthesis of real-world driving cycles using stochastic process and statistical methodology (2011), Int. J. Vehicle design, 57:1, pp. 17-36

[6] Johannesson, P., Podgórski, K., Rychlik, I., Shariati, N., AR(1) time series with autoregressive gamma variance for road topography modeling (2017), Probabalistic engineering mechanics 43, pp. 106-116.

[7] Maghsood, R., Johannesson, P., Detection of steering events based on vehicle logging data using hidden Markov models (2016), Int. J. Vehicle design 70:3, pp. 278-295.

[8] Chalmers project page, Real world CO2 assessment and vehicle energy efficiency (COVER), url: https://research.chalmers.se/en/project/?id=8239 (sep 2018)

[9] Pär Pettersson, Pär Johannesson, Bengt Jacobson, Fredrik Bruzelius, Lars Fast, Sixten Berglund. A statistical operating cycle description for prediction of road vehicles' energy consumption. Transportation Research Part D: Transport and Environment 73, 205-229, 2019.

[10] Erik Nordström Advanced Modelling and Energy Efficiency Prediction for Road Vehicles, Masters thesis Umeå University, 2020.