Volvo Predictive Maintenance Solution

field study

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Volvo, and in particular Volvo Technology, has been developing methods for predictive maintenance and for detecting abnormal system behaviour for several years. This project is a field study aiming to evaluate available algorithms in the context of long-haul trucks.

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1. Background and Motivation

The number of embedded computers on-board modern vehicles is growing continuously, and the data exchanged among them contains a lot of information about the state of the system. It is now becoming possible to get access to numerous signals over data networks (such as CAN), coming from sensors, control units and fault codes. It is also becoming feasible to embed software agents into on-board hardware, with the goal of listening to this data and learning to distinguish between normal and faulty operation, as well as to estimate component wear and evaluate quality of control parameterisation.

The typical approach to system monitoring of various equipment, including vehicles, is typically based on the reference model built off-line, by domain experts, from design and test data. Access to real-world data through telematic technology allows us to supplement this model with knowledge of history and behaviour of other vehicles operating under similar conditions. Data gathered on-board one truck can be compared against other vehicles in the same fleet, and deviations can be detected as soon as a particular system starts to operate differently from *its own* expected behaviour, not necessarily from the globally acceptable profile.

2. Methodology

The project started with design and implementation of data logging equipment. One requirement on the system was to have it completely automatic once deployed, with all the data from trucks being transferred over wireless network. Since it is not possible, at this stage, to continuously transmit all the important signals, a decision was made to only log data at “interesting” moments, based on certain trigger conditions.

Such triggers include starting the engine, running at high torque and low speed, and similar situations. The idea behind those is that both faults and wear are most clearly visible when the system is under stress. The appropriate definition of those trigger conditions is not an easy task, since they need to be designed in such a way that enough data from various conditions is captured to provide necessary description of vehicle behaviour, but at the same time they need to limit the total amount of data so that it stays manageable.

The data collected in the project will be analysed using artificial intelligence and data mining methods, based on the ideas explored in previous projects. The plan is to start by obtaining "normal" value characteristics of each signal, as well as finding interesting relationships between signals. Those aggregated attributes can then be compared across vehicles and across different times in order to determine the meaning and causes of detected deviations.

An assumption in the project is that six months of data collection may not be enough to see concrete results in increased uptime but it should give us an understanding of the similarities and differences between trucks, as well as self-organised model of how various signals relate to each other. Such vehicle characterisation is going to be an important step in moving towards the successful use of such methods in a product.

3. Results

The data logging equipment is now installed and working on 10 long-haul Volvo trucks in the USA, and we have several weeks of data available. Initial analysis of this data has been performed, but there are still discussions regarding which components we should focus the data mining efforts on, and what are the exact form of results that we should be aiming for.

It is also still unclear how big of an issue the "snapshot" nature of the data will turn out to be, since preliminary results show that the frequency of different triggers is quite uneven between different vehicles, which makes the data more difficult to compare. The techniques to handle this issue are currently under investigation.