Predictive Diagnostics:
Enhancing Machine Learning Algorithms in Automotive Engineering

Engineers have equipped automobiles with tremendous amounts of sensors in order to monitor and understand the complex interdependent systems. Predictive diagnostics is one example of recent developments where modern machine learning algorithms are exploited for automotive applications. The focus is on prediction of prospective component failures by combining state-of-the-art machine learning algorithm with the expertise of automotive engineers. Such automated predictions have multiple folds of advantages such as:

a. Avoiding critical component failure on the road
b. Monitoring the life of the component for re-engineering based on field failures
c. Pre-ordering components to ensure availability at the workshop

Challenge

Selection of the relevant dimensions (e.g. sensor measurements) is an essential step for the prediction of component degradation. Machine learning algorithms are sensitive to irrelevant dimensions, which can mislead algorithm and raise false alarms. Currently, automotive engineers choose relevant dimensions manually by their domain expertise and their understanding of the underlying systems. Such manual analysis is a very time consuming process as one has to consider the search space of all possible combinations of dimensions. Given several hundreds of sensors today and the increase amount of sensor measurements in the future, it is essential to exploit automatic techniques that can enhance both prediction and the understanding of complex automotive systems.

In particular the complex interdependency of dimensions is challenging for both engineers and machine learning algorithms. Dimensions are data streams that monitor different metrics such as pressure, temperature, speed etc., which all show some non-linear dependencies. Furthermore, in the near future predictive diagnostics will be extended to several other automotive components, with even more sensors becoming available and more dependencies observable by multivariate sensor measurements. Current manual analysis of such huge and complex data can take several months of expert time for each component, and thus will not scale in the future scenarios.

Our project aims at assisting automotive engineers by development of enhanced feature selection technique for the automatic identification of the relevant dimensions. We will base on statistical selection schemes and provide efficient algorithms that scale well with the number of dimensions provided. After selection of relevant dimensions, the results are to be verified by automotive engineers. Hence, we need to design an intuitive way to interactively explore and explain the detected interdependencies to engineers. Feature selection algorithms should not be considered black box tools from statistics. After our project, automatic feature selection should enable enhanced understanding and interpretation of dependencies by automotive engineers and scale with their huge and complex data resources.

Project Description

Bosch will provide sensor data from different components that has been recorded during component tests. The project will focus on using this field data with real-time values of several sensors and various data types (e.g. binary, nominal, ordinal, and continuous).

The students have to handle the following tasks during the project:

1. Implement enhanced feature selection algorithms
    a. Consider different correlation measures from the machine learning literature
    b. Consider different search strategies to prune the exponential search space
    c. Define novel scores that reflect correlation of dimensions and user interest
    d. Develop algorithms that steer search strategies based on domain expertise
2. Develop an interactive exploration framework for feature selection.
3. Evaluate the tool on large data sets and analyze efficiency and scalability.
4. Evaluate the quality of feature selection by regular feedback from automotive engineers.

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