Improving temperature models using Machine Learning Techniques

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Popular Science Summary

Abstract :

Temperature estimation models are crucial for various products manufactured by BorgWarner. These models often require manual calibration, where experts adjust parameters to ensure accuracy. However, this process can be slow and prone to errors. This thesis investigates how Machine Learning techniques can be used to improve accuracy and efficiency of temperature models.

The performance of certain products manufactured by BorgWarner relies on a temperature model to estimate the temperatures of clutch plates and oil. These estimated temperatures are used to control the pump and prevent mechanical damage due to overheating. The need for these temperature estimates arises from the high costs associated with the implementation of temperature sensors. However, even with good sensors, it is challenging to measure clutch plate temperatures that can increase by 100 to 200 degrees Celsius in just a second.

The goal of this thesis was to improve this temperature model by using machine learning techniques, which can learn from data and make predictions. Both black-box and grey-box approaches are used to evaluate the effectiveness of machine learning-based calibration. The black-box model employs techniques such as Decision Trees, Random Forests, and Neural Networks to predict temperature directly from raw input data, bypassing traditional temperature estimation processes. The grey-box model, on the other hand, uses Deep Q-learning to adjust the calibration automatically.

The grey-box model aimed to automate the process of tuning parameters in the temperature model. Normally, experts have to manually calibrate these parameters, which takes time and can lead to errors. The grey-box model used Deep Q-learning technique which allows the system to learn and adjust parameters automatically. This approach significantly reduced the manual effort needed for calibration, by as much as 90%.

The black-box model was a more direct approach. Instead of tuning parameters, it used machine learning techniques to predict temperatures from raw data inputs such as sensed temperature from the PCB, motor speed, pump current, among others. This method bypassed traditional estimation processes and gave accurate temperature predictions.

Overall, the results showed that both the grey-box and black-box models could improve the accuracy and efficiency of temperature estimation in cars. The grey-box model was especially effective at reducing manual calibration effort, while the black-box model showed potential for making quick and accurate temperature predictions.

This work could help car manufacturers save time and resources in calibrating temperature models. Additionally, it enhances vehicle safety by reducing the risk of overheating through more accurate temperature predictions. This work suggests that machine learning can play a valuable role in improving automotive technology and paves the way for further research in this area. The full version of the thesis is available for download from: https://lup.lub.lu.se/studentpapers.