

Target Cascading of Tire Performances using Machine Learning

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This research addresses a critical challenge in Model-Based Systems Engineering (MBSE) for automotive tire development: establishing tire performance targets at the early development stage without physical testing. The study proposes and validates a Target Cascading (T/C) process that derives tire performance targets from vehicle performance requirements using machine learning. Previously developed prediction models for tire and vehicle performances were improved and refined, and a user-friendly graphical interface was developed to integrate these models with the T/C process for practical implementation.

The automotive industry is transitioning from physical testing toward virtual development through MBSE. However, tire development faces a fundamental paradox: MBSE requires predefined tire performance targets to build accurate models, yet determining these targets is difficult at the architecture phase when only limited information is available and physical testing is infeasible because engineers cannot get any real tires. Additionally, since tires affect all vehicle performances, not only pure tire performance items such as rolling resistance or traction, but also tire-vehicle interactions such as NVH, subjective handling and ride comfort, comprehensive consideration of all performances is necessary.

To overcome this contradiction, the research significantly improved two core prediction models. The tire performance prediction model was enhanced by expanding number of tire design parameters involved from 11 to 24 and number of tire characteristics from 26 to 54. The full-vehicle performance prediction model which predicts 73 vehicle performance indices was improved the prediction accuracy by retraining with the expanded tire design parameters and tire characteristics. Both prediction models predict not only mean values but also feasible performance ranges of tire characteristics and vehicle performance indices.

The Target Cascading process was developed by integrating optimization technique with these prediction models in an iterative workflow: tire design parameters generate predicted tire characteristics, which then predict vehicle performance indices. If predicted vehicle performance indices fail to satisfy targets, the system updates tire characteristics and re-predicts vehicle performance indices until all vehicle performance targets are satisfied. The identified tire characteristics are then designated as tire performance targets. A graphical user interface was developed to integrate these whole process. Fig. 1 illustrates the complete workflow and Fig.2 shows main interface of GUI.

The proposed T/C process was validated optimizing tire performance to improve vehicle handling. Synthetic measurement data and FTire model was used for the validation. Results show that the maximum deviation between target and optimized results was only 10%, demonstrating practical effectiveness.

This research successfully eliminates physical testing dependency for tire performance target setting and enables simultaneous consideration of all vehicle performance aspects (handling, ride comfort, NVH, durability). By resolving the fundamental MBSE contradiction, it provides a practical framework that facilitates tire development's transition toward virtual and systems-based engineering, significantly improving development efficiency.

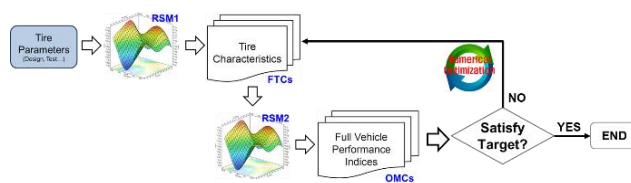


Fig.1 Workflow of T/C process



Fig.2 Main interface of GUI