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Diploma Thesis:

"Hybrid Modeling Combining Physical Models and Neural Networks on the Example of a Motor Vehicle"

Abstract:

Considering the increasing automation in all domains, computer based modeling has gained substantial significance. As we approach new and more complex application areas the requirements on flexibility, accuracy and real time behavior increases. In the face of those requirements it is often impossible to accept the specific limitation of individual model classes.
This work analyses a number of hybrid architectures combining neural networks and physical models of dynamic vehicle behavior. The simulation results for some hybrid architectures show significant enhancement of data accuracy on most datasets. This work proposes additionally a novel approach to the estimation and readjustment of the vehicle weight mass based on the changes in dynamic behavior.

Summary and Conclusion:

This work demonstrates the possibility to improve the results of a physical model significantly by using an appropriate hybrid modeling architectures. In particular, structural errors and erects of measurement errors can be reduced. The dynamic nature of the problem causes state discrepancies if the model parameters (e.g. mass) are incorrect: the simulated vehicle is still moving whereas the true car stands already. This state mismatch has severe impact on the global model performance and the presented simple hybrid architectures are not capable to address this problem directly. However it is possible to deduce such parameter errors from model residuals and to re-estimate the particular parameter as demonstrated on the example of mass. The introduction of physical constraints and clear separation of different process states has improved the reliability and accuracy significantly.
There are no standard criteria to select particular hybrid architecture. The choice of data, architecture and parameter can however be supported by simple data analysis methods and domain knowledge.
Hybrid models will play a greater role in the future of dynamic modeling applications since the requirement on accuracy is constantly increasing. Theoretical models are converging towards the limits of known physical dependencies. It can be expected that the future development of hybrid models will lead to more complex and special purpose models that are optimized for the particular task.

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