Human Senses Mimicking

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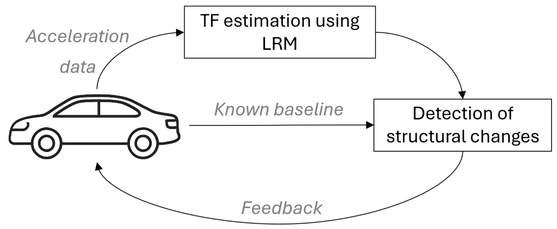
Introduction

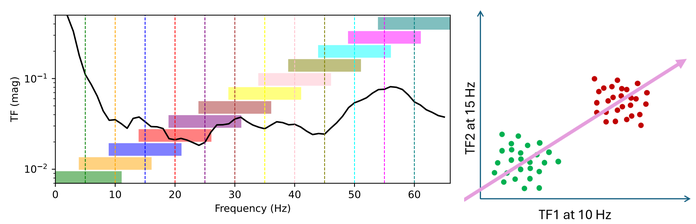
Structural faults in vehicles can compromise safety and performance, especially in autonomous systems witout human senses. This study introduces a robust method for detecting structural changes using frequency-domain system identification and sparse classification models to identify fault-specific indicators.



Research problem: Detect deviations in the structure of a car compared to a baseline state using acceleration data, while remaining robust to road and speed variations.

Method

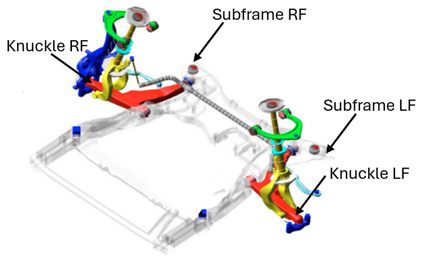
The system is modeled as a linear dynamic relationship between input and output signals. For each time window of measurement data, the transfer functions (TFs) are estimated between accelerometers. These estimations serve as features for fault classification using a L1-regularized logistic regression.

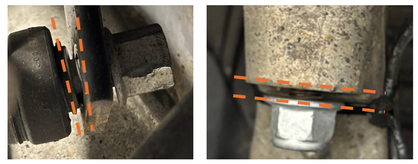


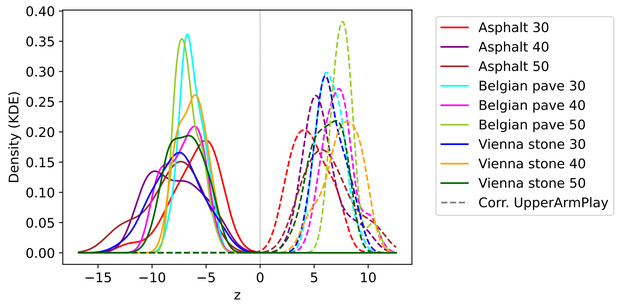
Results

Experiments were conducted on a Volvo XC90 using two triaxial accelerometers on the front wheel knuckles (inputs) and two on the subframe (outputs). Measurements were taken across three road surfaces and three speeds for both baseline and faulty setups of the car.

Five faults were induced independently of each other. The pictures depict two of them: play in anti-roll bar and play in upper control arm.



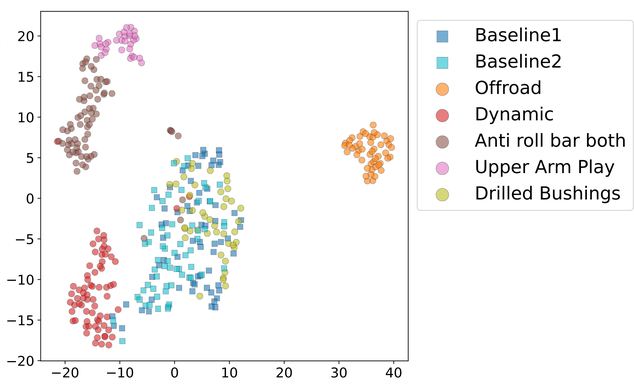




The model reliably separates baseline and faulty data regardless of road and speed variation during training. The graph shows the separation for upper control arm fault. Similar performance is obtained for the other tested faults.

High validation accuracy was obtained for all faults except the case of a modified bushing. Fault classification of the five faults are visualized in a t-SNE plot. Only validation data is used.

Fault	Accuracy	False alarm
Offroad	100.0 %	0.0 %
Dynamic	98.3 %	3.3 %
Anti-roll bar	99.2 %	1.1 %
Upper control arm	100.0 %	0.0 %
Drilled bushing	75.7 %	25.7 %



Conclusions

Faults undetectable by human drivers were successfully identified by the algorithm. The sample by sample detection accuracy is high, but it will decrease when tuning the algorithm for an acceptable risk of false alarms. Future work should investigate this tuning and increase the detection accuracy using information from consecutive time windows.

Driving SEDDIT's vision

The method enables fault detection from sensor data, supporting automated decision-making in vehicles. This increases the vehicle safety and reduces the environmental impact by improved vehicle reliability.

Acknowledgments

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