Human Senses Mimicking

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Introduction

A driver of a vehicle has the possibility to sense a changed structural behavior of a car due to differences in noise or vibrations. To enable autonomous drive (AD) the mechanical structure of the vehicle has to be monitored to guarantee its drive-ability. The aim of this project is to develop a live fault detection system of the structural behavior of a car. A prestudy resulted in a working prototype [1, 2] with room for improvements.

Method

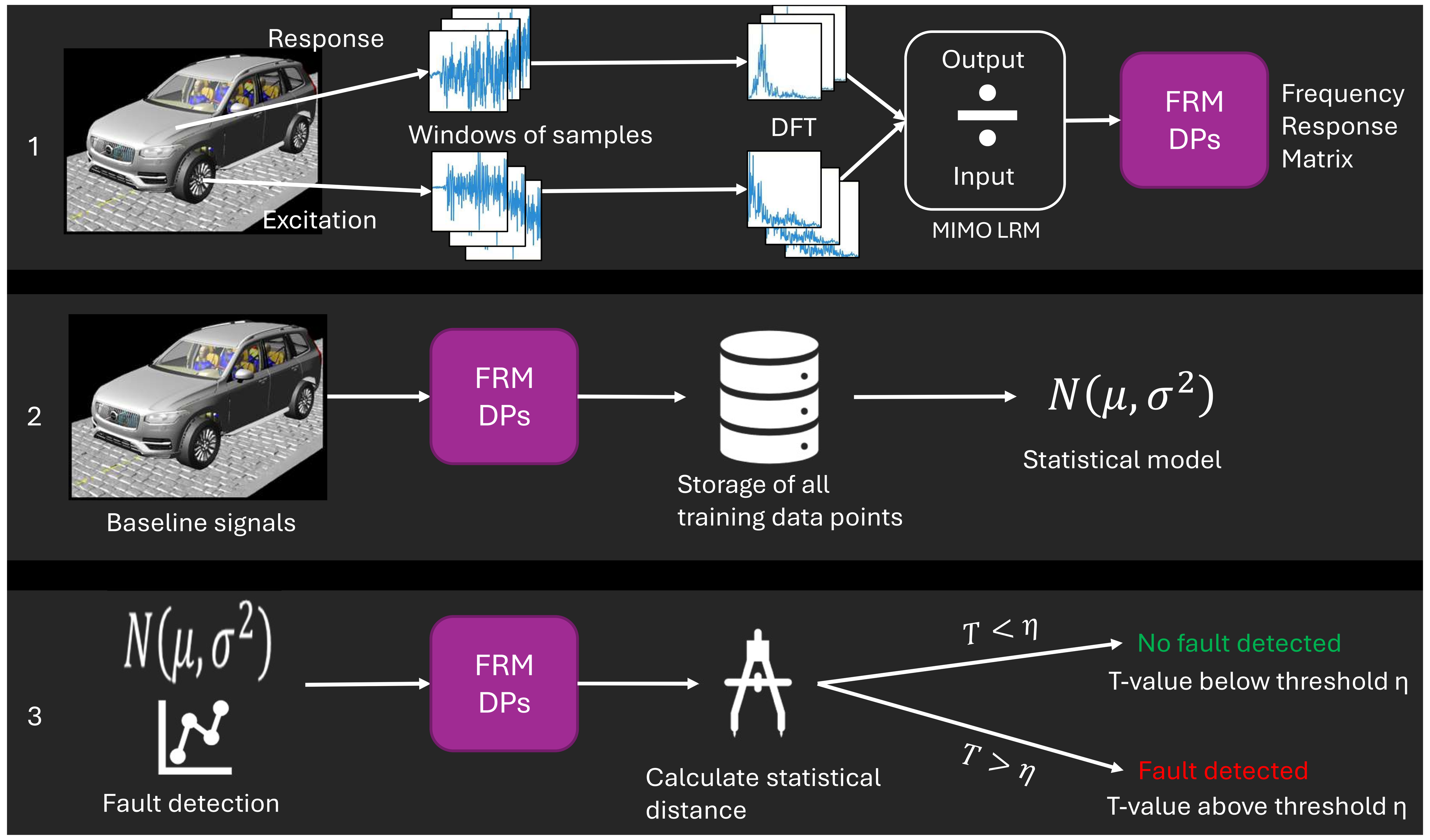
The prototype can detect faults that are difficult for a driver to notice. The detection is almost real time with only a small delay of 4-8 seconds. Currently changes in road surface is incorrectly detected as a mechanical fault.

The system architecture consists of three main steps.

1). Creation of multidimensional data point. Measured signals are cut into short-duration samples. Within each sample, signals are grouped into excitation and response signals depending on their position in the vehicle. Time signals are converted into the frequency spectrum with discrete Fourier transform and a MIMO local rational model (LRM) system identification method is applied to the input-output relation, yielding a frequency response representation of the system. This matrix-valued function is evaluated at a number of frequencies to create the data point.

2). Training during baseline conditions. A statistical model (normalized multivariate complex Gaussian model) is fitted to the comparatively large set of obtained multidimensional data points at ordinary operational conditions.

3). For live damage detection, data points are continuously measured and compared with the baseline to calculate the statistical distance. If the distance (T-statistics) is above a user-set threshold value then a fault is deemed detected.



There are several open questions to address with this approach, such as how to identify what differs an actual mechanical fault from a change of road conditions? How to identify different types of faults? What is the optimal training data sequence and at which frequencies? What is the optimal sensor placements?

Short term actions

Before addressing the open questions, following short term actions are planned for the upcoming couple of months.

- ✗ System Identification course.
- ✗ Navigating through scripts from prototype build.
- ✗ Setting up virtual machine environment in CAE cluster.
- ✗ Recreate SQL-database in virtual machine.
- ✗ Enable version control for existing code using GitHub.
- ✗ Write test cases for existing code.
- ✗ Create a working prototype on the CAE cluster.

Summary

The prototype will be further developed with the aim to create a robust live fault detection system of the structural behavior of a vehicle. It is desired to work on different road conditions and categorize the type of fault.

Acknowledgments

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References

[1] D McKelvey. *Detection and monitoring of mechanical faults in vehicles*. MSc thesis, Chalmers University of Technology, 2022.

[2] McKelvey D. Nordberg P. McKelvey, T. A multivariate local rational modeling approach for detection of structural changes in test vehicles. *IFAC PapersOnLine*, 2021.

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