Identification for Control of Heavy-Duty Diesel Engines via Parametric and Local Parametric Approaches

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1 Introduction

Heavy-duty diesel engine manufacturers are challenged to decrease fuel consumption while NO_x emissions are strictly regulated. Therefore, these engines are equipped with an increasing number of sensors and actuators, such as an exhaust gas recirculation (EGR) valve and a variable geometry turbine (VGT). This provides advanced means to control the combustion process. To systematically design such multivariable controllers, a model-based approach is pursued. The required models can be obtained through first-principles modeling or system identification [4]. However, first-principles models are often very complex, expensive, and inaccurate for high performance control design.

2 Approach

The approach considered in this research is based on a non-parametric model of the system, similar to [4], followed by a multivariable parametric model [3] fitted upon these measurements. Hence, an accurate model can be identified that is also suitable for model based control techniques. Furthermore, the local rational method (LRM) [1, 2] is employed to perform the non-parametric identification. Compared to classical spectral identification methods, the LRM has superior suppression of leakage (transient) errors and it contains noise averaging properties that are at least as good as time-domain windowing techniques [1].

3 Results

The engine dynamic behaviour is strongly varying at different operating points (engine speed, load, ambient conditions), which need to be identified independently. Consequently, the "fast" method adaptation of the LRM is applied to approximate the local dynamics as this method allows a full identification of the multivariable plant with a single experiment, leading to essential time reduction compared to other multivariable identification techniques. The LRM locally approximates the transient and the plant G by a rational function, shown in (1).

$$G(\omega_{k+r_E}) = \frac{N(\omega_{k+r_E})}{D(\omega_{k+r_E})} = \frac{\sum_{s=0}^{n_G} g_s(k) r_E^s}{1+\sum_{s=1}^{n_D} d_s(k) r_E^s} \qquad (1)$$

This rational function, consisting of a polynomial numerator and denominator of order n_G and n_D respectively, estimates the response at frequency ω_k by a least squares fit through the local window r_E of adjoining excited frequencies. Figure 1 shows an LRM estimation based on three periods of a 100s multisine, compared to a robust measurement consisting of 26 experiments of six 100s multisine periods each.

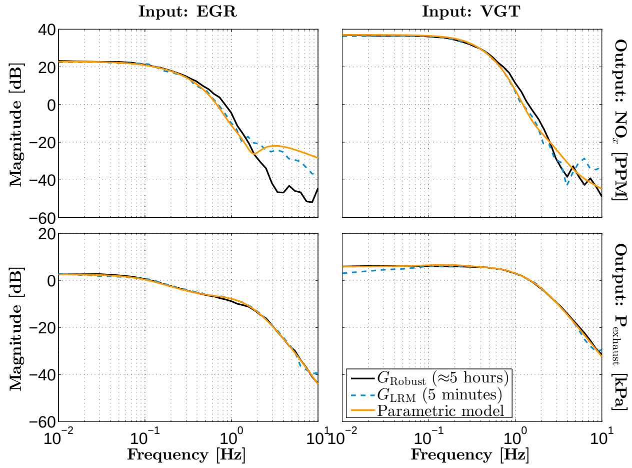

Figure 1: Magnitude bode plots of the LRM estimate, the robust estimate and the parametric model of the plant from EGR and VGT to NO_x and exhaust manifold pressure.

The LRM estimate is a close approximation of the robust benchmark, the covariances (not shown) are estimated with similar precision. A parametric modelling procedure [3] capable of identifying the common dynamics of the system is applied to the LRM estimation. The resulting parametric fit is shown in Figure 1 as well.

4 Future work

In future work, more control inputs will be included in the model such as fuel injection timing, quantity and pressure, extending the system size up to 6-by-6 elements. Furthermore, a broader range of operating points will be identified and a multivariable controller will be synthesized.

References

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