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Citation for published version (APA):

Document status and date:
Published: 01/01/2016

Publisher Version:
Publisher’s PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:
• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher’s website.
• The final author version and the galley proof are versions of the publication after peer review.
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Download date: 03. Jun. 2020
Identification for Control of Heavy-Duty Diesel Engines via Parametric and Local Parametric Approaches

Lars Huijben†‡, Thijs van Keulen†‡ and Tom Oomen‡
‡DAF Trucks N.V., Eindhoven, The Netherlands.
L.I.Huijben@student.tue.nl, T.A.C.v.Keulen@tue.nl and T.A.E.Oomen@tue.nl

1 Introduction
Heavy-duty diesel engine manufacturers are challenged to decrease fuel consumption while NOx 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).

\[
G(\omega_{k+T_E}) = \frac{N(\omega_{k+T_E})}{D(\omega_{k+T_E})} = \frac{\sum_{r=1}^{n_G} g_r(\omega) r_E^r}{1 + \sum_{s=1}^{n_D} d_s(\omega) r_E^s} \tag{1}
\]

This rational function, consisting of a polynomial numerator and denominator of order \( n_G \) and \( n_D \) respectively, estimates the response at frequency \( \omega_k \) 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.

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