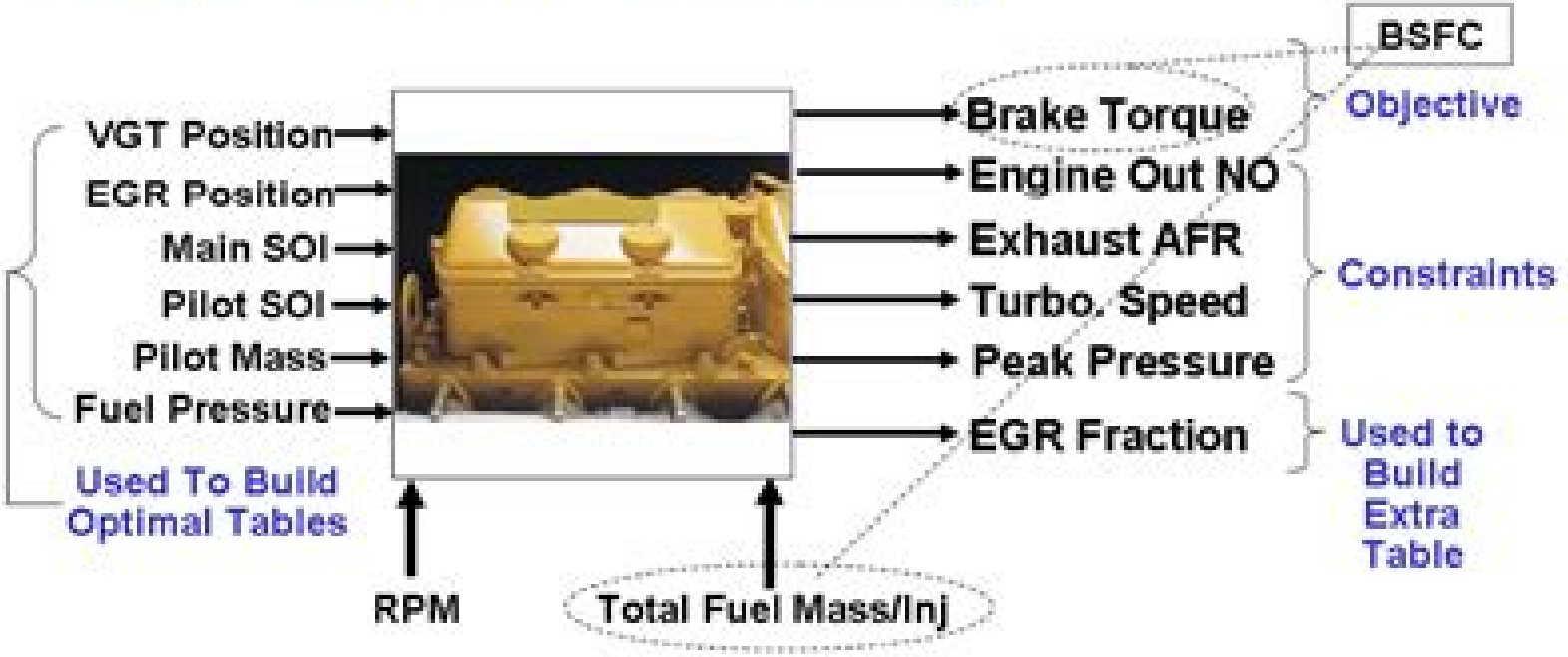
Example CI Engine Calibration Problem

- Optimization Problem Setup



Minimize mode-weighted brake specific fuel consumption, subject to multiple mode-based output constraints

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Optimization For Engine Calibration Engopt

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Modeling and Optimization for Stationary Base Engine Calibration Benjamin Berger,2012 **Optimization of Automotive Engine Calibration for Better Fuel Economy** J. E. Auiler,J. D. Zbrozek,P. N. Blumberg,Society of Automotive Engineers,1977 *Application of Multidisciplinary Design Optimisation to Engine Calibration Optimisation* Xuefei Yin,2012 *Historia del muy esforza do cavallero el Cid Ruy Diaz Campeador ,* **Artificial Intelligence and Data Driven Optimization of Internal Combustion Engines** Jihad Badra,Pinaki Pal,Yuanjiang Pei,Sibendu Som,2022-01-05 Artificial Intelligence and Data Driven Optimization of Internal Combustion Engines summarizes recent developments in Artificial Intelligence AI Machine Learning ML and data driven optimization and calibration techniques for internal combustion engines The book covers AI ML and data driven methods to optimize fuel formulations and engine combustion systems predict cycle to cycle variations and optimize after treatment systems and experimental engine calibration It contains all the details of the latest optimization techniques along with their application to ICE making it ideal for automotive engineers mechanical engineers OEMs and R D centers involved in engine design Provides AI ML and data driven optimization techniques in combination with Computational Fluid Dynamics CFD to optimize engine combustion systems Features a comprehensive overview of how AI ML techniques are used in conjunction with simulations and experiments Discusses data driven optimization techniques for fuel formulations and vehicle control calibration Optimal Test Signal Design and Estimation for Dynamic Powertrain Calibration and Control Ke Fang,2012 With the dramatic development of the automotive industry and global economy the motor vehicle has become an indispensable part of daily life Because of the intensive competition vehicle manufacturers are investing a large amount of money and time on research in improving the vehicle performance reducing fuel consumption and meeting the legislative requirement of environmental protection Engine calibration is a fundamental process of determining the vehicle performance in diverse working conditions Control maps are developed in the calibration process which must be conducted across the entire operating region before being implemented in the engine control unit to regulate engine parameters at the different operating points The traditional calibration method is based on steady state pseudo static experiments on the engine The primary challenge for the process is the testing and optimisation time that each increases exponentially with additional calibration parameters and control objectives This thesis presents a basic dynamic black box model based calibration method for multivariable control and the method is applied experimentally on a gasoline turbocharged direct injection GTDI 2 0L virtual engine Firstly the engine is characterized by dynamic models A constrained numerical optimization of fuel consumption is conducted on the models and the optimal data is thus obtained and validated on the virtual system to ensure the accuracy of the models A dynamic optimization is presented in which the entire data sequence is divided into segments then optimized separately in order to enhance the computational efficiency A dynamic map is identified using the inverse optimal behaviour The map is shown to be capable of

providing a minimized fuel consumption and generally meeting the demands of engine torque and air fuel ratio The control performance of this feedforward map is further improved by the addition of a closed loop controller An open loop compensator for torque control and a Smith predictor for air fuel ratio control are designed and shown to solve the issues of practical implementation on production engines A basic pseudo static engine based calibration is generated for comparative purposes and the resulting static map is implemented in order to compare the fuel consumption and torque and air fuel ratio control with that of the proposed dynamic calibration method Methods of optimal test signal design and parameter estimation for polynomial models are particularly detailed and studied in this thesis since polynomial models are frequently used in the process of dynamic calibration and control Because of their ease of implementation the input designs with different objective functions and optimization algorithms are discussed Novel design criteria which lead to an improved parameter estimation and output prediction method are presented and verified using identified models of a 1 6L Zetec engine developed from test data obtained on the Liverpool University Powertrain Laboratory Practical amplitude and rate constraints in engine experiments are considered in the optimization and optimal inputs are further validated to be effective in the black box modelling of the virtual engine An additional experiment of input design for a MIMO model is presented based on a weighted optimization method Besides the prediction error based estimation method a simulation error based estimation method is proposed This novel method is based on an unconstrained numerical optimization and any output fitness criterion can be used as the objective function The effectiveness is also evaluated in a black box engine modelling and parameter estimations with a better output fitness of a simulation model are provided Model Assisted Iterative Calibration of Internal Combustion Engines Anuj Pal,2021 Recent automotive technological advancements mainly focus on improving fuel economy with satisfactory emission levels leading to a significant increment of engine system complexity especially diesel engines This increases the number of engine control parameters making the engine calibration process challenging and time consuming using the conventional map based approach Note that engine calibration is a crucial step in achieving optimal engine performance with satisfactory emissions and it is an expensive process in general With the advancement and widespread adoption of machine learning methods for control applications it is now possible to use a black box model with intelligence to efficiently calibrate nonlinear systems without detailed knowledge of system dynamics The surrogate assisted optimization approach is an attractive way to reduce the total computational budget for obtaining optimal solutions This makes it special for its application to practical optimization problems requiring a large number of expensive evaluations The current research work focuses on the problem of performing engine calibration using the surrogate assisted optimization approach The objective is to find the trade off curve between engine efficiency in terms of brake specific fuel consumption BSFC and its NOx emissions by efficiently optimizing various control parameters The complete study is divided into three parts The first part deals with modifying the original algorithm for efficiently handling the practical system with

measurement noise A new constrained handling algorithm is proposed for lower confidence bound LCB criteria that showed good performance for both deterministic and stochastic systems Furthermore two extensions based on the expected improvement EI criterion are proposed for handling stochastic multi objective problems After the methodology development for handling stochastic systems the second part validates their efficacy for performing the engine calibration in a simulation setting All three algorithms are compared to identify the best approach for its implementation on the actual engine experimental setup Three control parameters namely variable geometry turbocharger VGT vane position exhaust gas recirculating EGR valve position and the start of injection SOI are calibrated to obtain the trade off between engine fuel efficiency performance BSFC and NOx emissions within the constrained design space The simulation study identifies the lower confidence bound LCB criteria with the proposed constraint handling approach to work well in the stochastic setting compared with the other two extensions Therefore this approach is used for the experimental evaluation of the proposed surrogate assisted optimization for engine calibration Finally the third part is the experimental validation It is the first step towards automating the entire engine calibration process Experimental evaluations are performed on a 6 7L Ford diesel engine to validate the algorithm s efficacy Problems with different complexity are formulated and evaluated using the proposed approach Initially a simpler problem with two control variables is formulated to get the confidence to perform the experiments using the proposed algorithm Two variables EGR valve position and VGT vane positions are calibrated to obtain a trade off between engine efficiency BSFC and NOx emissions After observing promising results the study is concluded with a more complicated three control variable problem An external electrically assisted boosting device eBoost is added to the engine system to perform calibration Results showed improved engine performance using the eBoost with a significant reduction in calibration effort in terms of the number of experimental evaluations The study successfully demonstrated the application of the surrogate assisted optimization approach to a practical engine system and opened the door to automate the engine calibration process with reduced calibration efforts Statistics for Engine Optimization Simon P. Edwards,Daniel M. Grove,Henry P. Wynn,2000 In 11 specially commissioned articles engineers and statisticians explain how they collaborate to use statistical techniques to expand the tool kit for designing engines demonstrating especially how statistically designed experiments can make a major contribution to meeting existing and future demands in engine development They discuss modeling techniques response surface methods multi stage models neural networks Bayesian methods optimization emulating computer models genetic algorithms on line optimization and robust engineering design Distributed in the US by ASME Annotation copyrighted by Book News Inc Portland OR *Application of Multidisciplinary Design Optimisation Frameworks for Engine Mapping and Calibration* Mohammed R. Kianifar,2014 **Physical-based Modeling of Engine Processes** Reza Rezaei,2018 **Development of an Automatic, Multidimensional, Multicriterial Optimization Algorithm for the Calibration of Internal Combustion Engines** Timo Burggraf,2015 Statistical Modeling With

Matlab Calibration Models Optimization and Optimization Analysis Olsen F.,2016-11-16 Model Based Calibration Toolbox contains tools for design of experiment statistical modeling and calibration of complex systems The toolbox has two main user interfaces Model Browser for design of experiment and statistical modeling CAGE Browser for analytical calibrationCAGE CAlibration GEneration is an easy to use graphical interface for calibrating lookup tables for your electronic control unit ECU As engines get more complicated and models of engine behavior more intricate it is increasingly difficult to rely on intuition alone to calibrate lookup tables CAGE provides analytical methods for calibrating lookup tables CAGE uses models of the engine control subsystems to calibrate lookup tables With CAGE you fill and optimize lookup tables in existing ECU software using models from the Model Browser part of the Model Based Calibration Toolbox product From these models CAGE builds steady state ECU calibrations CAGE also compares lookup tables directly to experimental data for validation CAGE can optimize calibrations with reference to models including single and multi objective optimizations sum optimizations user defined optimizations and automated tradeoff **Model-based engine calibration for best fuel efficiency** Christopher H. Onder,1995 Fundamentals of Powertrain Calibration David R. Rogers,Neil Coghlan,2025-01-01 Fundamentals of Powertrain Calibration offers a full guide to automotive electronic controller calibration covering all the information needed for efficient and effective calibration in both physical and virtual domains Intended as an introduction for those new to the subject as well as a valuable reference source for existing automotive engineers new to powertrain calibration tasks the book is written by expert authors from AVL the market leader in the field Beginning with the foundation knowledge needed to understand calibration complexity and automation the book moves on to cover the technology required to access the controller calibration data types and data analysis experimental approaches and modeling The first practical guide to automotive powertrain calibration with information on the topic currently fragmented held locally within companies or available only at a level requiring expert knowledge for comprehension Offers complete coverage from underlying principles to advanced aspects and future trends equipping engineers to understand carry out and improve calibration tasks and processes not just drive the software Written by expert authors from AVL the market leader in the field of powertrain calibration **Optimization of Engine Controls Using Geometric Programming** M. M. A. Dehghani,Hasan Sehitoglu,Society of Automotive Engineers,1983 **A Computerized On-line Approach to Calculating Optimum Engine Calibrations** John F. Cassidy,Society of Automotive Engineers,1977 **Simulation-based engine calibration** Cheolwoong Park,Eric Rask,Mark Guerrier,Nebojsa Milovanovic,2004 *Objective determination of minimum engine mapping requirements for optimal SI DIVCP engine calibration* Peter J. Maloney,2009 *Analysis of Engine Calibration Methods Used by an Automotive Manufacturer Using a Design Structure Matrix* Anneliese Herzog,2004 Calibration of Automotive Aftertreatment Models Through Co-simulation with MATLAB Optimization Routines James Mack,2016 New and existing government regulations mandate limits on various automotive exhaust tailpipe out species including but not limited

to Oxides of Nitrogen NOx Carbon Monoxide CO Unburned Hydrocarbons THC and Particulate Matter PM Automotive aftertreatment systems allow for the mitigation of harmful engine out species by converting pollutants into less harmful products by the time they reach the tailpipe Traditionally catalytic converters have been used in stoichiometric Gasoline Port Fuel Injected PFI applications for reduction of gaseous emissions while particulate filters have been used in diesel applications to reduce PM Gasoline Direct Injected GDI engines pose potential regulatory difficulties since unlike PFI GDI vehicles emit PM at levels near regulatory limits If manufactures cannot improve GDI engine control strategies to reduce PM levels a Gasoline Particulate Filter GPF may be a required addition to GDI aftertreatment systems GDI aftertreatment systems consisting of Three Way Catalytic Converters TWC and GPFs can be developed in commercial automotive powertrain modelling packages The performance of candidate component configurations can be virtually tested and evaluated however before this can occur individual components must first be calibrated to insure modelled performance is close to reality In this work 1 D models for both a TWC and a GPF were modelled in the powertrain modelling package GT Power GT P A simplified version of the kinetic set proposed by Ramathan and Sharma 42 was utilized within the TWC while the GPF was modelled as a non catalyzed filter with thermal PM oxidation kinetics Calibration was accomplished utilizing a series of optimization routines developed in MATLAB These routines tuned system parameters until simulation values matched experimental results GT P models were coupled to MATLAB using a communications block within Simulink Simulation values were passed from GT P to Simulink while tuning parameters in GT P were adjusted in MATLAB In total 17 parameters in the TWC and 6 parameters in the GPF were adjusted Calibrated models show reasonable agreement in terms of species conversion efficiencies filtration efficiency and pressure drop Details regarding the data analysis model development communications coupling optimization routines and results are presented herein

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