




Automotive Systems Design

Eindhoven University of Technology

PEng projects 2014



The Automotive Systems Design PDEng (Professional Doctorate in Engineering) degree programme is an accredited and challenging two-year doctorate-level engineering degree programme. During this programme trainees focus on strengthening their technical and non-technical competencies related to the effective and efficient design and development of technologies and applications for modern high-tech automotive systems. In particular, there is a focus on the multidisciplinary design aspects of project-based research and engineering in high-tech automotive systems, reflected in the key contributions by five TU/e departments.

The programme is organised by the Department of Mathematics and Computer Science of Eindhoven University of Technology in the context of the 3TU.School for Technological Design, Stan Ackermans Institute.

For more information, visit the website: www.3tu.nl/asd.

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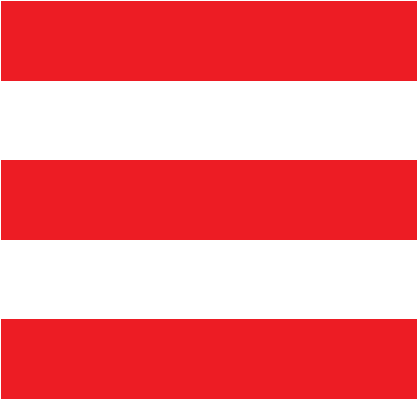
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Prof.dr.ir. M. Steinbuch

Dr. P.S.C. Heuberger

The second generation ASD trainees

It's with pleasure and pride that we present you the results of the 2014 graduates of the Automotive Systems Design PDEng programme. This programme was started in 2011, motivated by the urgent need of the automotive industry for system architects, people who are not afraid to go beyond the boundaries of disciplines and who are willing to work together in project teams to achieve desired results in a structural manner.

This two-year programme educates its trainees in-depth in various automotive related disciplines, as well as in personal and professional development. This variation in disciplines is reflected in the 6 projects that lie before you. We see applications and designs in the areas of Mechanical Engineering, Hybrid Electric Driving, Engine Control, Software Architecture, Modelling and Advanced Driver Assistant Systems. One project deals with the noise reduction of automatic transmission systems, another comprises the possibilities using data of a fleet of electric vehicles, with the aim to develop a smart charging infrastructure. Advanced driver assistant systems are playing a major role in automotive developments with the goal to enable fully automated driving within the next two decades. Among others these systems focus on collision avoidance. In a third project this was investigated for bicycles. One project was devoted to Software Architecture, in particular a software development methodology for high-end automotive components. In two projects trainees worked on heavy duty diesel engines. One project introduces a new single cylinder pressure sensor concept, while the other project aimed at the development of an aftertreatment model and integrating it on a Hardware In the Loop system.

The final projects, proposed by the high-tech industry are diverse, complex and challenging. They require our trainees to deliver products that meet high requirements in a very multidisciplinary setting. We are proud that that our trainees live up to the high expectations of the industry. We wish them all the best and a successful career.

Maarten Steinbuch
Scientific Director

Peter Heuberger
Program Manager



Challenges

The major challenge in this project was to handle the multidisciplinary background of the domain. Smart grid technologies, electric vehicles, middleware layer, and mobile applications from the functional and business perspective are a few examples of the broadness of the domain.

One more challenge was to handle the multi-stakeholder nature of the WSG project. A complex web of companies associated with each other was discovered from an extensive stakeholder analysis. Only VIBe consists of TU/e, NXP, Automotive NL, BOM, Daut Milieu and Autogroep Driessen.

Results

Almost twenty mobile applications were investigated divided in two main categories of smart mobility and energy management. Smart mobility consisted of the car management, fleet management, chain mobility and traffic management. Energy management was divided into the load management and green energy management. Other research areas that mass data from vehicles can be used were investigated. Examples are research institutes, governmental authorities and insurance companies.

Benefits

A starting point for the design process until the requirement elicitation of a number of applications was set. The CP Reservation & Smart Charging application, the EV path planner, the Seat market manager and the HTC EV parking solution were investigated in that perspective. On one hand mobility applications can serve the driver and facilitate processes that EV driving pioneers are struggling with currently. Load management on the other hand is an area of multi-purpose applications that serves the grid operators and the end user.

Marinos Aspragkathos PDEng

A systems approach to designing new mobility and smart grid services:

The World's Smartest Grid showcase



“Marinos wide ranging system analysis led to a host of recommendations for smart phone apps that can benefit the drivers of (electric) cars. I can hardly wait until this effort inspires the VIBe project, the TU/e or some innovative individuals to turn his recommendations in to actual apps!”

Auke Hoekstra
E-laad

The World's Smartest Grid (WSG) is a project initiated by the Vehicle Innovation Brabant electric (VIBe) along with the regional grid operator, Enexis, and the High Tech Campus (HTC) site management. The deployment of Electric Vehicles (EVs) to employees in the working areas of the HTC, the Automotive campus and the TU/e campus and the installation of Charging Points (CPs) in these areas are the first steps of the overall project.

The main objective of the WSG project and of VIBe is to develop a smart charging infrastructure, using a communication platform that will connect drivers, EVs and CPs with the grid operator and the Charging Point Operators (CPO) is the key factor of the infrastructure. The platform will be the base for a Living Lab that will be used for developing, testing and validating automotive services for the EV drivers, the commuters, the application developers etc. The aforementioned objective was the motivation that drove this project into investigating concepts and ideas of mainly mobile applications. The key question was how vehicle data can serve the end user starting from the smart charging service.

The WSG creates stepping-stone opportunities towards the technological breakthrough and innovation that goes beyond smart charging. The stakeholders' requirement was to expand the range of the applications to conventional vehicles. The information exchange infrastructure that is going to be established will facilitate the development of the mobility services. Activities around EV driving and transportation are facilitated by designing mobile applications. The first steps of the design process of applications concerning electric mobility, such as trip planner for EVs and smart charging & CP reservation, and transportation such as seat market manager were analyzed.

Challenges

The main challenge for the project is to develop the real-time TCPS system for transient engine conditions with acceptable accuracy. A trade-off between computation time and precision has to be defined while focusing on the system requirements. The available time window for in-cylinder pressure estimation is between hundred to twenty milliseconds varying depending on engine speed, making the real-time implementation of the complex system algorithms a challenge.

Results

In the TCPS project, an in-cylinder pressure sensor estimator system for heavy-duty engines is designed and the initial implementation on real-time rapid prototyping hardware is performed. The estimator performance is verified considering both conventional and advanced combustion cases for steady state and transient engine conditions. The project results prove that the proposed real-time estimator system for in-cylinder pressure estimation is a feasible solution for sensor reduction in combustion control applications.

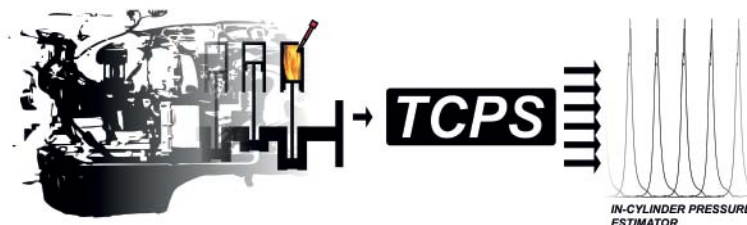
Benefits

In this project, it has been proven that the proposed in-cylinder pressure estimator is a possible solution for the cost issues arises with the usage of pressure sensors. Additionally, the TCPS reduces the required modification on heavy-duty engines with the reduction of required in-cylinder pressure sensors. If the requirements of combustion control from TCPS estimator are fulfilled, in the near future, TCPS can easily become a standard for heavy duty market.



Serkan Külah PDEng

Transient Cylinder Pressure Sensor Estimator for Heavy-duty Diesel Engines



“Not only did Serkan develop an algorithm that predicts individual cylinder pressure for highly dynamic diesel engine operation, he also managed to deal with the implications on software and hardware control architecture by his system engineering approach. With the practical realization on a Rapid Control Prototyping system, his work is an important step towards application of TNO’s TCPS technology in trucks.”

Frank Willems
TNO

With the introduction of mass production in-cylinder pressure sensors, closed-loop combustion control became feasible for engine control. This was beneficial for conventional diesel engines to enhance robustness against fuel quality variation, injector wear, (multi-pulse) fuelling accuracy and to optimize after treatment size. In addition, it enabled the introduction of advanced combustion concepts, such as Homogeneous Charge Compression Ignition, Pre-mixed Charge Compression Ignition and Reactivity Controlled Compression Ignition, that all rely on controlled auto ignition. Although research shows that closed-loop combustion control is promising, the system costs related to the in-cylinder pressure sensors are assumed to be unacceptably high for truck engines. Also pressure sensors increases complexity of cylinder head design.

This project introduces a new single cylinder pressure sensor concept for heavy-duty diesel engines. Using crank angle and in-cylinder pressure information from one cylinder pressure sensor, the unmeasured pressures in the five remaining cylinders are predicted by the combination of a real-time crank shaft model and an adaptation mechanism: so-called Transient Cylinder Pressure Sensor Estimator.

Using the system engineering approach, for a heavy-duty diesel engine, the potential of this concept is demonstrated under transient engine conditions. The simulation studies using experimental input data are performed for the estimator. It is shown that relevant combustion control parameters can be approximated with low inaccuracy, respectively. The TCPS implementation to real-time rapid prototyping hardware is also performed and system functionality is demonstrated.



Challenges

The main challenge of the project is to prove the correlation of the different NVH research activities in the company and to gain the fundamental understanding of the effect of different element sequences on the pulley noise behaviors. In addition, the project requires a flexible approach to bring the system view to a complex and specific topic of CVT.

Results

An analytical element impact noise model is developed that gives a fundamental explanation to the effect of different element sequences on the noise behaviors of the CVT pulley. In particular, the significant noise reduction of the OES belt compared with the standard belt is fundamentally proved by this model. Furthermore, the project work helps confirming the usability of the noise countermeasure of the element mixing technique.

Benefits

The resulted model shortens the time checking the noise behavior of new designed belt patterns. Moreover, new optimization algorithm can be applied on this model to obtain new optimized sequences.

Tuan Ngo-Ngoc PDEng

Optimized Noise Behavior for Pushbelt CVT

“We would like to thank Tuan for his great contribution to the development of the Optimal Element Sequence (OES) belt. Given his open mind and his creativity he was able to develop his own successful approach to this study which has resulted in a more fundamental understanding of the noise mechanism and recommendations to reduce the noise level.”

*Erik van der Noll
Bosch Transmission
Technology*



Located in Tilburg, the Netherlands, Bosch Transmission Technology B.V. is the market leader in the field of development and mass production of pushbelts for Continuously Variable Transmission (CVT). Since the Van Doorne's Transmissie B.V. (original name of Bosch Transmission Technology B.V.) was founded in 1972, the company continuously invests in the further development of the pushbelts and is accountable for numerous innovations. The competence center in Tilburg is being supported by specialized satellite offices in USA, China, Japan, Korea, and the second production plant in Ho Chi Minh City, Vietnam.

The use of Continuous Variable Transmission (CVT) in automotive applications has seen a remarkably strong growth worldwide. Customers appreciate the excellent fuel economy and high level of comfort of CVT equipped drivelines. Besides smooth shifting, the high level of comfort is driven by the good overall NVH behavior of the pushbelt. To be prepared for the required noise reduction as a result of the introduction of hybrid and electrical vehicles cooperation was started with the Technical University of Eindhoven. In preparation to the study of Tuan a previous member of the ASD program investigated the effect of different pushbelt element sequences on the noise level. Tuan Ngo focused more on the physical understanding of the noise phenomena. His work analyzes the impact events of the elements on the pulley surface and the response of the CVT pulley under those element impacts. Bosch will continue this research as recommended by Tuan and is discussing how to make use of the resulting model to the development of the Optimal Element Sequence (OES) belt.

Challenges

The main challenge of the project is to develop a methodology to design an efficient software architecture that makes the functional part of the software portable across different electronic control units (ECUs). This separates generic functionality from component specific functionality, improving reusability.

Results

The project resulted in introducing a structured way of designing, documenting and testing software. It defines a uniform procedure for software development. The V-model is used as a process model throughout the development of the software platform. It offers a framework that simplifies the relation between the requirements, design, implementation, validation, and verification of the software system.

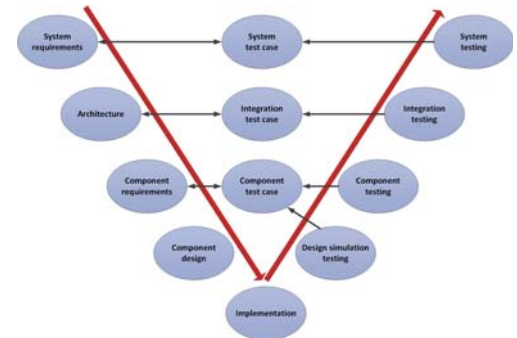
Benefits

The proposed methodology provides a logical sequence that helps to organize the complex activities of software development. This methodology provides guidance for planning and realization of the project, which results in minimizing project risks, reducing the total cost over the project life cycle, improving quality, supporting traceability between the artifacts, and improving communication between stakeholders.



Mahmoud Ravanan PDEng

A model-based software development methodology for high-end automotive components



“Mahmoud designed, though his background as mechanical engineer, a solid methodology to develop software. We appreciate him as a valuable and respectful colleague, with a strong will to learn and eager to reach project milestones.”

Roel de Natris
Benteler Engineering Services

Benteler Engineering Services (BES), in collaboration with a truck body builder and a small special manufacturer has built an electric-driven hydraulic refuse collection truck body, which can supply power for one shift of collecting refuse.

They aim to design and develop a more efficient electric body, which can supply power for two complete shifts of collecting refuse. This means that there is a need to develop software for controlling the battery, chargers, inverters, and other relevant components.

The V-model was used as a process model to develop an efficient software platform for the electric body of a heavy-duty refuse collection vehicle. It offers a framework that simplifies the relation between the system requirement specifications, the architecture, the component requirement specifications, the component design specifications, implementation, verification, and validation of the software system. Initially, the system requirement specifications were elicited from the customers' requirements. In the architecture design phase, the components were defined and using a traceability matrix the system requirement specifications were mapped onto the components. Then, the detailed requirements of the components were derived. In the design specification phase, the requirements of the components were used to obtain a detailed design of the components. In the implementation phase, the software components were realized based on their design specification using a modelling tool, i.e. Matlab / Simulink, and Stateflow. Finally, the components were tested to see whether the product has been built in a correct way.



Challenges

Cyclist protection is a technically challenging problem, as the cyclists group is possibly the most difficult to be classified among the vulnerable road users, due to the dramatic appearance changes of the bicycle according to its viewpoint. Also, cyclists demonstrate faster motion profiles, especially when driving e-bikes, compared to pedestrians; this aspect sets strict requirements for the real-time detection, warning and actuation systems.

Results

The CAFCR system engineering approach has been applied for the design of the advanced driver assistance systems for cyclist protection. Besides the overall system architecture, the design of the trajectory prediction methods, the bicycle model, the Hidden Markov Model for state prediction and the simulated vehicle-bicycle test scenarios have been implemented in Matlab. The verification and validation process has been performed on simulation level with simulated and experimental data.

Benefits

The feasibility analysis has yielded valuable conclusions about the designed and implemented bicycle trajectory prediction methods, where various input parameters were used, and the potential benefits of including the bicycle model in the prediction. Additionally, the technical and operational feasibility of a collision avoidance system that involves bicycle trajectory prediction has been investigated.

Anastasia Tegopoulou PDEng

Bicycle-Vehicle Trajectory Prediction and Collision Risk Estimation for Advanced Driver Assistance Systems



“Anastasia helped us a lot in describing a complete scope for the innovation project on cyclist safety that she took part in. She followed a system engineering approach for the project development and considered various design aspects. It was clear that she learned how to plan her work and she was always very well prepared for the meetings.”

Riske Meijer
TNO

Vulnerable road users, such as pedestrians, cyclists and motorcyclists, are more possible to be seriously injured in a crash with a car than the car occupants. In The Netherlands around 150 cyclist fatalities occur each year based on the statistics of the last ten years. As part of the “Safe and Green Mobility” technology roadmap, TNO takes a leading role in reducing the number of killed and seriously injured to a level of 20% below the goal of the Dutch government for 2020, which is five hundreds casualties per year. To achieve this target, TNO invests on innovative solutions for cooperative and automated driving.

This project is part of the TNO’s road safety strategy and focuses on the design of a novel advanced driver assistance system for cyclist protection. The designed system architecture involves the state prediction, the vehicle and bicycle trajectory predictions, and the collision risk estimation. Particular emphasis has been placed on the Matlab implementation of the bicycle dynamics model, state prediction, and trajectory prediction methods with various input parameters. The sensitivity of the bicycle trajectory prediction methods on their parameter tuning has been investigated and the validation results across experimental data have been analyzed. Also, the design determinants and risk issues of the in-vehicle system for cyclist protection have been investigated.

Challenges

The main challenge was to develop a complete Exhaust After-treatment System that could run stand-alone as well as on a HIL set-up and was reasonably accurate for immediate deployment in other projects within DAF. Investigating the limits of calibration possible with the available data and proposing what needs to be done for future calibration work was also challenging.

Results

A complete exhaust after-treatment model that can run stand-alone has been deployed on a HIL system. It has been shown to be robust and calibration has improved accuracy. Future proposals for calibration set-ups to further improve accuracy have been detailed. The model's usefulness has been exemplified in the area of diagnostics for sensor, actuator and process faults that pertain to exhaust after-treatment.

Benefits

This model can now be used for the development of control and diagnosis applications pertaining to engine and after-treatment systems, both in the context of development on stand-alone units as well as on the HIL set-up.



Jonathan Z. Vasu PDEng

Exhaust After-Treatment Modelling and Integration on a Hardware-In-Loop System



For development and prototyping of engine control and diagnosis software

“Jonathan’s contribution in developing an aftertreatment model and integrating it on a Hardware In the Loop system pushed us forward in calibrating and validating engine and aftertreatment On Board Diagnostics. Although the task was very challenging Jonathan delivered a solid base for future projects and improvements.”

*Gert-Jan van der Heijden
DAF Trucks N.V.*

Emissions norms continue to become more stringent as government agencies and industry work together to improve the environment and general health and safety levels. Current regulations under the “Euro VI” standard have been enforced across the European Union since the beginning of 2014 for new registrations. Automotive manufacturers have introduced various innovations in order to ensure compliance to the evolving standards over the last twenty years. An important recent innovation in the truck market is the Exhaust After-treatment System (EAS) that sits downstream the engine. Through filters and catalyst bricks, NO_x emissions and Particulate Matter (PM) emissions are reduced to very low levels, to a fraction of what is produced by the engine.

Hardware-In-Loop (HIL) simulators are valuable tools to enable quick development and prototyping of control, engine management and diagnostic solutions. These are quicker, cheaper and more flexible than traditional test-bed based approaches and are indispensable for research and development, especially in the very competitive automotive market.

Development of engine models for use in HIL set-ups allows for a large degree in flexibility for testing new configurations, control and diagnostic solutions. In this project, exhaust after-treatment models were developed and calibrated and then integrated on a HIL system. As an application example, the model was shown to be useful for fault diagnosis by injection of certain sensor, actuator and process faults. The model is expected to be the foundation for future modelling and calibration development within DAF Trucks N.V. and is expected to be of particular interest to the control and diagnostic groups within DAF during development of relevant solutions pertaining to exhaust after-treatment.

Credits

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