3TU.School for Technological Design

STAN ACKERMANS INSTITUTE

TU Delft Delft University of Technology

TU/e Technische Universiteit Eindhoven University of Technology

UNIVERSITY OF TWENTE.

Automotive Systems Design

Eindhoven University of Technology

PDEng projects 2015

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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Automotive Systems Design - PDEng projects 2015

Prof.dr.ir. M. Steinbuch
Dr. P.S.C. Heuberger

The third generation ASD trainees

It's with pleasure and pride that we present you the results of the 2015 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 post-master 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 12 projects that lie before you. We see a wide range of applications and designs in the areas of Mechanical and Materials Engineering, Software and Functional Safety, the Internet of Things, Automotive Control, Modelling and Advanced Driver Assistant Systems (ADAS). These ADAS systems are playing a major role in automotive developments with the goal to enable fully automated driving within the next decades. Three projects deal with ADAS applications for heavy duty trucks: automated docking, blind spot detection and lane change support. Another project aims to develop an integrated friction estimator, to be used in various applications. Software plays a very important role in Automotive applications nowadays. Two projects focus on the safety aspects of automotive software including the software architecture (functional safety and fail safety). Two projects deal with the production process and measurement technologies for the Continuous Variable Transmission system. One project discusses the possibilities and challenges that the Internet of Things creates for fleets of electric vehicles. In another project a measurement methodology was developed for pinion units in gearboxes. The development of new tyres is a timely and costly process. One trainee developed a system for the virtual development of tyres, that results in a decreased time to market and at the same time increases the tyre performance. The legislation on pollutant emissions puts huge challenges on the automotive industry. To control these emissions high quality measurements techniques are required. One project was devoted to the design and implementation of a real-time virtual NOx sensor for diesel engines.
These final PDEng projects, proposed and payed for by the high-tech industry are diverse, complex and challenging. They require our trainees to deliver products and designs that meet high requirements in a highly 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 main challenge of the project was to find a way to measure accurately preload of a bearings arrangement in a manufacturing channel. A target measurement methodology has to meet the following customer requirements: it has to be applicable in a manufacturing channel and its execution time has to be within the set time limit. In addition, only a small amount of changes in the differential gearbox is allowed and the cost of a unit production should not be significantly increased.

Results

As an outcome of the project, a new promising methodology has been developed. The methodology provides the accuracy within the required range and satisfied all the customer requirements. The developed methodology has a wide range of applications that are not only limited to differential gear units but also could be applied to the different components with taper roller bearings arrangements.

Benefits

A pinion unit has one of the major influences on the differential gearbox performance. Its working capabilities depend on the value of the preload applied between the two taper roller bearings. Due to the developed methodology, the step towards lower fuel consumption, reduction of CO_2 emission, and improvement of the drivetrain efficiency has been made. This preload measurement methodology has a high potential to enhance the reputation of SKF Group, an engineering knowledge company, in the original equipment manufacturer market and increase its bearing market shares.

Filip Cichosz PDEng

Pinion Unit Preload Measurement

Design of the Preload Measurement Methodology for the Tapered Roller Bearing Arrangement in the Truck Pinion Unit

"Filip has played a fundamental role in developing a full methodology to precisely detect the preload set in a taper roller bearing arrangement for a final pinion drive of a truck, where the needs of stiffness and low friction are 2 conflicting but critical parameters to control and optimize. His proactive and enthusiastic approach to the project allowed himself and SKF to reach the challenging goal set."

Alessandro Garrone
Senior Product Development Engineer. Innovation and Advanced Development, Automotive Market

SKF is a leading bearings and seals manufacturing company. It has over 100 years' experience of innovation and continuous development of technologies, new products, solutions, and services. The SKF Engineering & Research Centre (ERC) located in Nieuwegein, the Netherlands is the central R&D facility in SKF worldwide.

Bearings, in order to work properly in systems like e.g., truck differentials, require a certain amount of preload. A wrong adjustment of preload leads to a range of problems. Examples of such problems are an increased amount of friction and a reduced lifetime. Nowadays, preload is set during a manufacturing process by the trial and error method. A value of the applied preload is estimated using the push pull methodology (measuring the displacement while the push and pull forces are applied). However, this method allows to obtain the value only within the accuracy from ± 30% to ± 50% that is three to five times the desired one.

Fuel consumption is directly related to friction in a powertrain. Due to a constantly increasing demand by truck manufacturers, transportation euro standard, and environment euro standard for a low fuel consumption and reduction of the exhaust emissions, a proper preload adjustment can be seen as a step towards the fulfilment of these demands. Therefore, the development of a methodology that provides the desired level of accuracy is needed. The project realized by Filip introduces a new preload measurement methodology that is focused on the deformation and displacement of components in trucks' differential pinion unit.

Challenges

The main challenge of the project was to find the optimal speed-accuracy trade-off. To facilitate future cycle-to-cycle control strategies, this virtual sensor is intended to estimate NOx formation within 25 ms and with an accuracy that is comparable to an actual sensor (90%). Due to the complexity of the physics-based combustion model and the limitations of the hardware (floor-space), a smart solution which optimizes the hardware usage was required.

Results

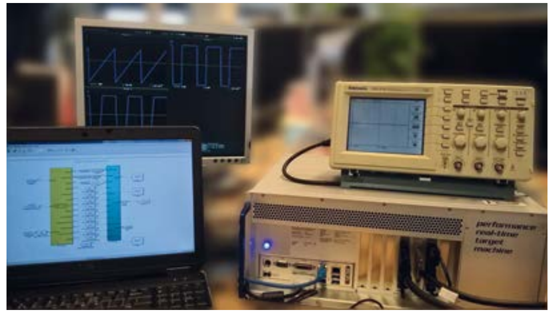
A real-time virtual NOx sensor was implemented and tested on a state-of-the-art FPGA-CPU-based rapid prototyping board. Several design decisions and model reduction were applied to obtain a successful implementation. This virtual NOx sensor was tested in a Hardware In the Loop (HIL) setup and proved to be fast and accurate enough for cycle-to-cycle control with a processing time of 6.9 milliseconds and an accuracy of 90%.

Benefits

A fast and accurate NOx sensor is believed to enable fuel consumption reduction. By exploiting the NOx-fuel consumption trade-off, margins in the engine calibration can be reduced both in the laboratory and during real-world operation. This virtual sensor increases the added value of the relatively costly cylinder pressure sensor, while eliminating the need of the costly current (engine out) NOx sensor. Also, engine monitoring and diagnostics capabilities can be extended.

Daniel Escobar Valdivieso PDEng

Design and Implementation of a Real-Time Virtual NOx Sensor for Diesel Engines



"Daniel successfully demonstrated the feasibility of fast and accurate NOx emission estimation based on TNO's physics-based combustion model. Following a system engineering approach, he managed to deal with the implications on software and hardware control architecture. Based on his Hardware-In-the-Loop demonstration, we are currently preparing for cycle-to-cycle NOx estimation on a 6-cylinder truck engine."

Frank Willems
TNO

Driven by societal concerns about environment and energy security, automotive industry faces enormous challenges to find an optimal, cost-efficient balance to realize drastic CO2 reduction while still complying with legislation to meet ultra-low pollutant emissions, such as Nitrogen oxides (NOx) and Particulate Matter (PM). Attention in legislation is shifting from test cycles in laboratories to on-road pollutant emissions. At the same time, up to 20% reduction in CO2 emissions (and fuel consumption) is discussed.

Cylinder pressure-based control is a promising route to enhance robust engine performance, in real-world operation. Using in-cylinder pressure information, we can compensate for the impact of variations, such as ambient conditions, component ageing and wear, and fuel quality, on fuel efficiency, torque response, and emissions. The application of this cylinder pressure sensor raises concerns related to system costs, engine complexity, and durability.

TNO recently demonstrated a single cylinder pressure concept by combining a crank shaft model with one pressure sensor. By further increasing the added value of the cylinder pressure sensor, TNO also aims to predict in-cycle NOx formation for each cylinder by extending the current model. This physics-based model describes the effect of the multi-pulse fuel injection on NOx formation. With the real-time implementation of this model, we will realize a so-called virtual NOx sensor. We follow a system engineering approach to successfully implement the system on a FPGA-CPU based rapid prototyping board. The virtual NOx sensor is proved to be real-time and to meet the accuracy of the actual sensor for the tested scenarios.

Challenges

The major challenges in the project were to cope with different hardware limitations, such as that of the steering actuator and lane detection sensors.

Results

A functional prototype of the Vehicle Lateral Position Control System is developed and successfully demonstrated at DAF. Feedback from the testing department has been used to tune the system.

Benefits

The developed Vehicle Lateral Position Control System was a first, promising step towards a system that can be demonstrated next year in the EcoTwin project. In addition to showing the potential of such a system several recommendations have been made with regards to hardware selection and system design. The lessons learnt during this project can definitely help in further improvement of the system.

Ashwin Dayal George PDEng

Vehicle Lateral Position Control System

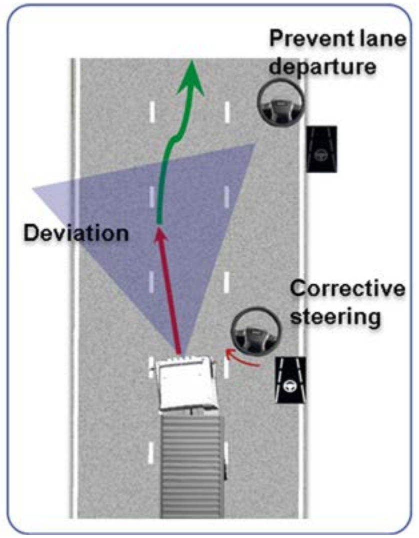
"Although the project objectives in combination with the 9 month time frame were considered very challenging, Ashwin took up the challenge. During the project he proved to be a reliable trainee: actions were completed in time and when agreements were made, you could count on him. Each project milestone he again surprised the management and team with his clear presentations. In the end, the project was concluded with a successful demonstration of the developed functionality on the DAF proving ground."

Jeroen Vandenhoudt
Vehicle Definition,
Ride & Handling at
DAF Trucks NV

As the Automotive industry moves towards the exciting realm of autonomous driving, changes in legislation and the availability of active steering systems have propelled the development of advanced driver assistance systems (ADAS) for the commercial vehicle industry (truck industry). As DAF explores semi- or fully autonomous trucks, the company is active in the EcoTwin project.

For the EcoTwin 2 demonstration to be given in 2016, a system is designed which can keep the vehicle, via active steering, within the lanes on a highway: i.e. the Vehicle Lateral Position Control System.

The system was implemented in a DAF XF Euro 6 prototype, making use of dSpace hardware and software tools. The system was tested and tuned on the high speed ring at DAF proving grounds. This project has laid the foundation for future development of an active lane keeping system for DAF.



Challenges

The main challenge for this project was to go through the full cycle of the V-model, starting from requirement definition, then designing the system, and going all the way up to implementation.

Results

A fully functional prototype that can automatically dock has been created, demonstrating technological feasibility of the auto docking system. The chosen control concept behaves very similar to simulated results in practice, proving a strong link between theory and implementation.

Benefits

Auto docking is one of the major steps towards fully autonomous driving, which is the ultimate goal on the ADAS roadmap. Demonstrating the technical expertise to apply it in practice opens new doors for further development towards fully autonomous operation. For customers this system can bring a large increase in safety and efficiency, as well as a reduction in property damage.

Thierry Kabos PDEng

Auto Docking

Design and implementation for a semi-trailer truck

"Thierry is a positive and cooperative trainee. He reacts quickly on requests from colleagues within the ADAS team. Meetings are always well-prepared, the quality and quantity of the delivered work is impressive, and it's remarkable to see how Thierry is able to deal with changes in project planning. All this resulted in a successful demonstration of the Auto Docking system on the DAF proving ground!"

Rudolf Huisman
Senior Control Engineer
at DAF Trucks N.V.

With the increased interest in Advanced Driver Assistance Systems (ADAS), truck and car manufacturers are constantly trying to expand the functionality of their vehicles, increasing customer benefits and overall safety on the road. An interesting avenue on the ADAS development roadmap that the commercial vehicle industry is working on, relates to automation in warehouse and docking environments. In this project an autonomous docking system was designed, which ultimately resulted in a functional proof of concept on a prototype vehicle.

For automated docking, the main economic benefit can be gained with full integration of the truck into the docking logistics system, allowing the driver to exit at the gates and saving a great deal of waiting time. The proof of concept of this project is a first step towards this scenario, as electrical control system components on the dock are part of the system design, which includes vehicle to grid communication.

To test the designed system it was implemented on a DAF Euro VI truck, making use of dSPACE Rapid Control Prototyping (RCP) hardware and software. Additionally, a dummy dock was constructed, where the necessary dock-side components of the system could be mounted. After implementation and testing, the designed architecture and control concept have proven successful in parking the truck autonomously at the dock!

Challenges

TNO is in business for developing innovations for automated driving and vehicle safety functions. With the recent trend of automated driving technologies, ensuring safety and functional safety of the advanced solutions is an ever increasing challenge. Especially considering the immense requirements that standards and norms such as ISO 26262 demand for developing safety critical systems; finding the balance between TNO's needs and the standards is not straight forward.

Results

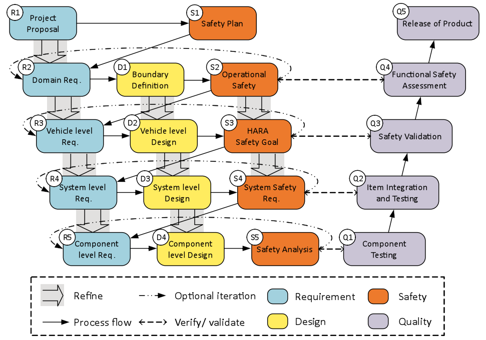
In this project, by analyzing TNO's way of working and safety life cycle recommended in ISO 26262, an integrated process based on parallel execution of two V-model processes was suggested. Moreover, the Architecture Framework for Functional Safety (A2FS) was introduced. This framework, based on conventional system engineering methods, offers an integrated architecture design by linking architectural elements to safety activities and work-products. In addition, in in this project lightweight safety engineering guidelines, suitable for TNO's small/medium size projects were created.

Benefits

The results of this project have a number of impacts for TNO. TNO can benefit from following the methods introduced in this study and provide its industrial customers with products/concepts that have better safety integrity or are ready to be produced in a safe way. TNO will be able to address the industry demands for functional safety and compliance with ISO 26262. Moreover, by revising the way of working of TNO, an opportunity for optimizing the project development process and adapting to system engineering guidelines is created for TNO.

Arash Khabbaz Saberi PDEng

Functional safety methods for developing automated driving functions



"Arash has taken up the challenge to develop this new methodology as the topic of his graduation assignment. He executed this assignment with a high level of ambition, using the skills and experience of the PDEng education effectively, with very promising results. Still, there are sufficient academic challenges related to this topic and we welcome that Arash will extend his work towards a PhD-thesis as a new colleague at TNO."

Sven Jansen
TNO

TNO works on developing safety critical automated driving functions. This study aims to address the problem of integrating functional safety into the development process and the way of working of TNO. The ISO 26262 standard is used as the reference for functional safety. This problem has been addressed from different aspects, development process, methodology, tools, and system architecture.

This project is divided into two major phases: Methodology design, and Case study. To solve the design problem, the CAFCR method is implicitly used. In the Case study phase the proposed solutions are tested in a small scale case study in order to validate applicability of the results.

As part of the Design methodology, the integration of functional safety in TNO's way of working is analyzed, with emphasis on two sides of the problem, i.e. ISO 26262 and TNO's way of working. The significant aspects of both sides are combined and connected using the CAFCR method. This phase resulted in the Functional Safety Methodology (FSM), which combines the proposed integrated design process, and Architecture Framework for Functional Safety (A2FS). The resulted integrated V-model can be seen in the picture.

The case study showed promising results for the methods. The integrated V-model has the potential to efficiently realize functional safety in the design process.

This project creates an opportunity for TNO to adapt to the state-of-the-art methodologies in system engineering and design. Moreover, it opens the way to play a role in the evolution of automotive systems' architectures.

Challenges

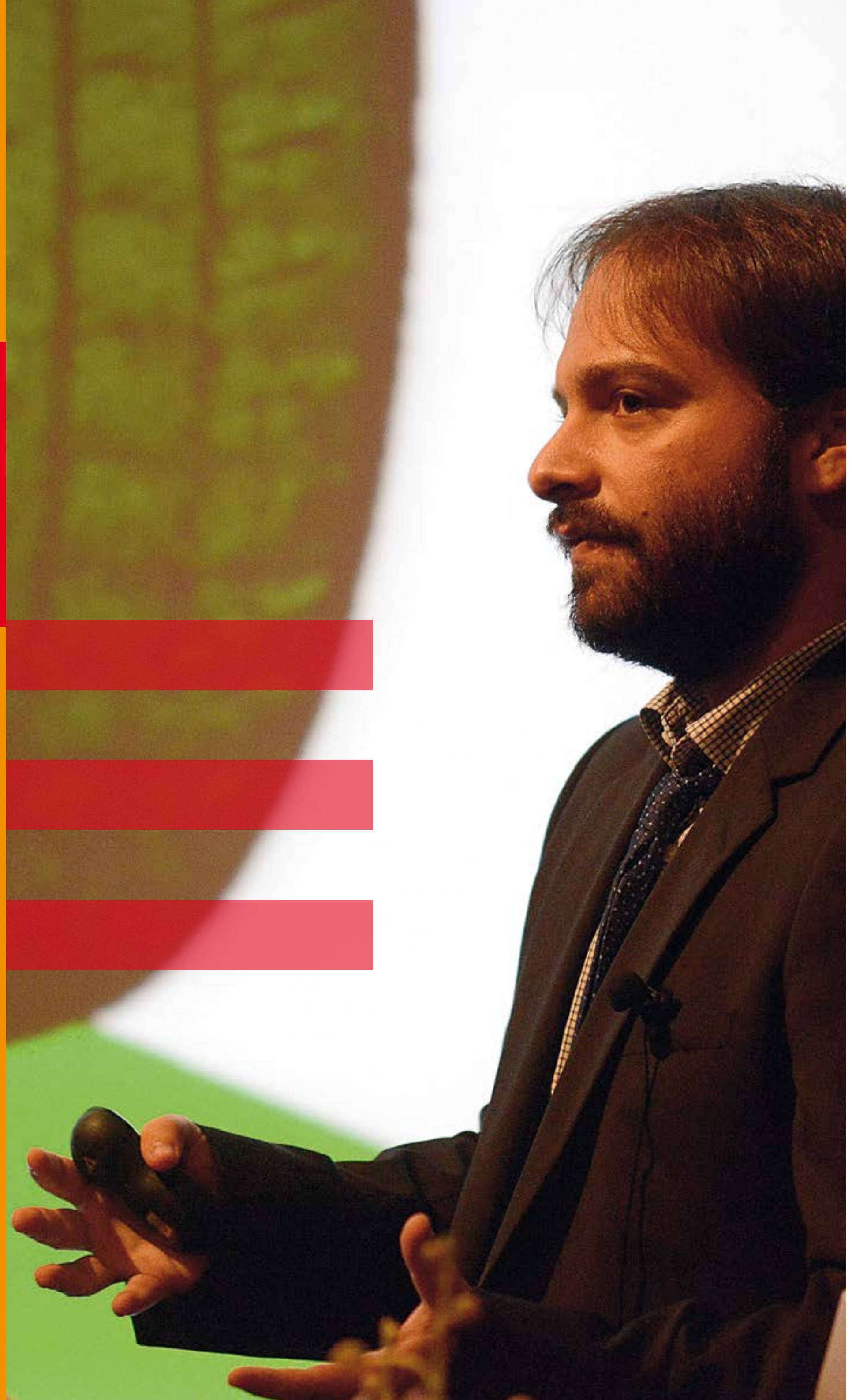
The main challenge of this project was the development of a novel procedure translating the complex tread designs of the tread pattern of tyres (the different blocks and grooves that interact with the road) into meshed models. Furthermore, the new process had to be integrated with the development process of the company.

Results

A geometric algorithm was developed converting the draft tread designs to meshed models. The algorithm tackles the problems of hexahedral meshing. Moreover, the new tool enables the functionality of separating the different materials of the designs and the integration with the FEA models. Finally, the tool proved to be robust against different designs.

Benefits

The generated process significantly decreases the time to develop a virtual tyre, which will result in decreased time to market. Moreover, it enables more design iterations which will lead to increased tyre performance.



Ioannis Konstantinou PDEng

Virtual Tyre Development

An automatic hexahedral tread mesh generator

"Ioannis managed to develop a fast and robust tool that automatically converts 2D tyre designs into 3D Finite Element models. Thanks to his perseverance and creativity, we now have a tool that can be seamlessly integrated in the current development process and enables us to develop tyres with decreased time-to-market."

Eelco Verhulp
Senior Researcher at Apollo Tyres Global R&D B.V.

Located in Enschede, the Netherlands, Apollo Tyres Global R&D is part of Apollo Tyres Ltd, a tyre manufacturing company. The company started in India in 1972 and currently it has grown in an international company with eight manufacturing facilities in Asia, Europe and Africa. The company's tyre products are for passenger cars, commercial vehicles, off-highway vehicles, agriculture vehicles and two wheelers, and they are available in over than 100 countries.

Introduction of EU tyre labels for rolling resistance, wet grip and tyre/road noise together with increasing performance demands from both OE and replacement customers are making product life cycles longer. Hence, virtual development has become more and more important to develop innovative tyre designs and enable decreased time-to-market.

In order to enable virtual prototyping and testing, complex 3D CAD drawings and FEA models have to be created. As such, a lot of effort is put in the development of new designs and simulation tools to automate as many tasks as possible. The most challenging part in the virtual development of tyres for passenger vehicles is the 3D tread pattern.

The aim of this project was to analyse and optimise the current process for the virtual tyre development. The main goal was the generation of an automatic hexahedral meshing procedure in order to translate new designs to FEA models.

Challenges

A major challenge of the project is that heat treatment modeling is a highly input-sensitive process. The simulations require a considerable amount of material data which is usually quite hard to acquire experimentally. Moreover, there is no in-depth knowledge about the influence of heat treatment versus saddle height growth available yet within Bosch.

Results

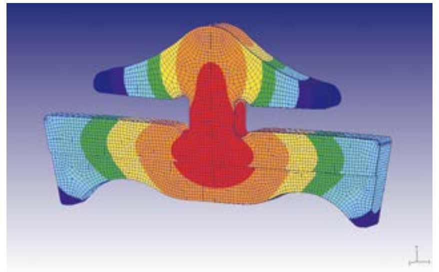
In this research, the heat treatment modeling is applied to predict and control the element distortion after the heat treatment process. Experiments and computer simulations were conducted and the results have been compared to evaluate the validity of the proposed model. The comparison revealed a good match for the element distortion, surface hardness and diffusion.

Benefits

The heat treatment process can be successfully simulated by computer models. This means that the output can be also predicted and controlled within the desired tolerance limits. The computer simulation of the heat treatment allows for the optimization of the hardening process with respect to particular product parameters in a later stage of development.

Dimitrios Maris PDEng

Establishing of a theoretical model for the saddle height



"We would like to thank Dimitri for his major contributions for the element heat treatment simulations. He has shown significant effort in understanding the fundamental factors mainly influencing the element distortions from the heat treatment. He also worked from scratch with respect to development of this complex modeling and has shown major improvements."

Hariharan Raja
Bosch Transmission Technology B.V.

Bosch Transmission Technology B.V. is the market leader in the field of development and mass production of pushbelts, the heart of the Continuously Variable Transmission (CVT). Located since 1972 in Tilburg, the Netherlands, and initially founded as Van Doorne's Transmissie B.V., the company continuously invests in the further development and optimization of the pushbelt. With more than 300 car models today using a pushbelt, the CVT market has seen a sharp increase in the number of applications. For Bosch Transmission Technology this increase in demand means large steps in production numbers.

The Bosch pushbelt consists of mainly two semi-finished metal products; the elements and the loopsets. Both have defined critical product parameters that have to be monitored and met in production, to guarantee product reliability and lifetime. For the elements, one of these parameters is the so-called saddle height. In the production line, the steel elements are heat treated in order to improve their physical and mechanical properties. After the heat treatment, an unpredictable variation of the saddle height is observed between different production batches.

The work of Dimitrios Maris provides a fundamental understanding of the relationship between the element distortion and the heat treatment conditions. Understanding the saddle height growth and being able to predict it will result to an increased productivity and lower rejects. Bosch will continue towards the direction proposed by Dimitrios Maris by further developing the heat treatment process models.

Challenges

In the field of IoT, standards and procedures to follow is still not common knowledge and not used widely yet. To identify the necessary elements to build the suitable IoT architecture for VIBe was the major challenge. Also the requirement from the stakeholder to help with setting up a consortium based on VIBe required proper planning and execution with strong networking skills to bring the various parties together.

Results

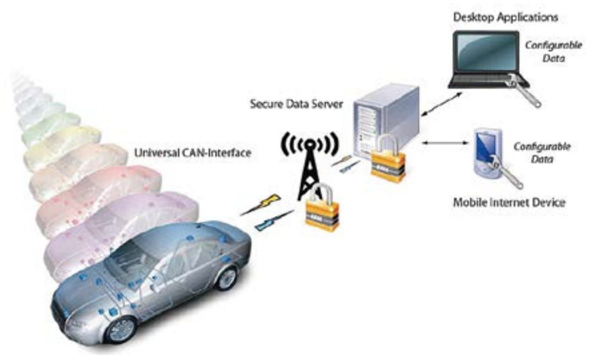
An IoT architecture with detailed views taking into account the concerns of the different stakeholders of the platform i.e the end-user, the app developer and the platform admin was developed. Applicability of several new concepts like fog computing, messaging based protocols and ontology engineering to the VIBe platform was analysed in this project.

Benefits

With the world moving towards Industry 4.0 and hyper-connectivity, the idea and value proposition put forward by VIBe is highly beneficial. The proposed architectural design and the design choices can act as the basis for further developments with regards to VIBe in the coming days.

Preethi Ramamurthy PDEng

An IoT architecture for cloud connected electric vehicles



"A paradigm shift is going on; mobility solutions integrate with smart grids, sustainability initiatives, the transition to electrical transportation, changing mobility use concepts entering the new promising world of Cyber-Physical Systems (CPS). Preethi has done a commendable job coming up with fresh ideas for technologies that help to tackle the challenge we have in VIBe; CPS enabling standardized and secure cloud connected cars."

Hans Brouwhuis
NXP Semiconductors/ VIBe

With more than 50 billion devices expected to be connected to the internet by the year 2020, the value proposition which Internet of Things (IoT) offers is tremendous, both in terms of money as well as opportunities. By taking advantage of the technology that IoT offers, it is possible to solve problems in key domains like health, energy and mobility. In the case of VIBe (Vehicle for Innovation Brabant - electric), the technology is used to solve the problems of electric vehicle (EV) users. While the EV usage and deployment is a leading case, the suggested solution from VIBe is not limited to electric cars and can be used to all means of mobility in general.

Vehicle for Innovation Brabant-electric (VIBe) was started by a group of companies in the Brain- port region of the Netherlands in order to develop a common communication platform for electric vehicles making use of the fast growing field of Internet of Things (IoT). The VIBe initiative consists of the steering group members coming from parties like NXP, BOM, Driessen Autogroep, TU/e and Automotive NL. Several other parties are also involved in this initiative like Beijer Automotive, Vtron, Sioux technology, Sycada Green and so on.

The main idea behind VIBe is to act as an enabler of several businesses by enabling applications to be built on the VIBeX API. VIBe was started to enable businesses in the Brainport region of Netherlands to make best use of the existing infrastructure and orient their businesses to benefit from Industry 4.0. The other motivation behind VIBe is to integrate knowledge from various domains like charging, EV-car, weather, etc by placing the intelligence in the cloud.

Developing an open source platform in the form of API (Application Programming Interface) is the solution for enabling connectivity in the IoT world and an architecture design using IoT concepts was analysed in great detail in this project. The key issue with developing such an open source API in the automotive field is the lock-in of information and usability of data from cars due to the IP protection from OEM's. The closed nature of such information systems hinders the development of innovative applications. The main goal of VIBe is to end the vertical oriented industry outlook and to champion the cause of enabling IoT based services in the Brainport region of Netherlands. This in turn drives the economic growth of this region and opens up new arenas for innovation.

Challenges

The challenge was to design a reliable tyre road friction estimator under normal driving conditions i.e. constant velocity and low acceleration driving. This means that the vehicle system undergoes only small excitation. Real time friction estimation restricts the algorithm in terms of computation and allowed memory usage. The estimation is performed with measurements from sensors currently existing in the vehicle which results in limited measurement accuracy. Methods of friction estimation only exist in the research field.

Results

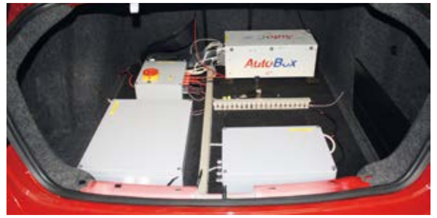
From the two methods investigated, one of the methods was successfully applied to both simulations and real data. It was concluded that the friction estimator is able to detect not only changes in tyre road friction but also the absolute friction coefficient under favorable conditions. Furthermore, the results encourage further development at TNO.

Benefits

Knowledge of the friction potential of the tyres on the road surface before any maneuvers are started is highly beneficial to increase the automation level in a vehicle. In this respect it is of importance to estimate the friction during normal driving conditions. Additionally, it reduces the dependence on the driver to judge the road surface and enhances the vehicle ability to anticipate emergency situations.

Rishabh Dev Sharma PDEng

Development of an Online Friction Estimator



"Rishabh, who did not have a background in the field of tyre and vehicle dynamics, had to acquire quite some knowledge about tyre behaviour, vehicle dynamics, vehicle behaviour and sensors. Also the usage of real world data and the fact that every small component appeared to be of importance at such low vehicle acceleration levels was challenging. Nevertheless, Rishabh managed to realize the first concept designs of the algorithms, which will be further developed at TNO."

Antoine Schmeitz
Senior Research Scientist
at TNO

With higher level of vehicle automation, the importance of knowing the vehicle capabilities that are mainly determined by the tyre road friction increases. This project is a step forward in accomplishing the goal of developing a friction estimator that can provide consistent estimates of tyre road friction under normal driving conditions. Two approaches to estimate the tyre road friction during straight line highway driving are presented. The estimator provides friction estimates in real time and uses measurements obtained from currently existing vehicle sensors.

The first approach known as slip slope estimation consists of using the wheel slip i.e. the relative difference in wheel velocities along with the tyre forces to estimate the tyre road friction. This method was applied on simulation and tested on real data for the driven wheels. The slip slope estimator is able to detect changes in friction during low and high excitation of the system. Additionally, the estimator accuracy for estimating absolute tyre road friction is considerably increased when it is well excited.

The second approach known as resonance peak estimator involves analyzing the vibrations of the tyre detected by the ABS wheel speed sensors. This method was applied on simulation and tested on real data. From simulations, it was shown that this estimator is able to detect different friction surfaces on the basis of mainly the identified damping. Also first application of the estimator on real data has begun, but more research and development work is necessary to draw conclusions.

Challenges

Before the decision making algorithms can be run, the road situation needs to be perceived correctly. Thus, the main challenge and risk of the project is creating a robust object detection system.

Results

The system has been developed and tested for an initial set of use cases. Proof-of-concepts of both systems demonstrated the ability to detect the object and to take appropriate action depending on the risk level.

Benefits

This project was a first step in the conceptual phase of a near object detection system and has laid a foundation for function development towards future applications on trucks.

Ivan Surovtcev PDEng

Concept study on Blind Spot Detection / Passive Lane Change Assist systems

Design and implementation for a truck

"Despite all the challenges that Ivan had to deal with he managed to realize a proof-of-concept functioning on a prototype truck. He was very dedicated to his task and his perseverance brought him to the desired end result. The work that Ivan delivered is very useful for us and forms a good basis for the next steps in the development of driver assistance systems."

Johan Broeders
Vehicle Property Owner and Specialist Safety and Braking at DAF Trucks N.V.

The Blind Spot is the area around the vehicle which is not directly visible for the truck driver while driving or standing still. The obstruction of the driver's vision makes him unaware of the objects inside the blind zone and, consequently, may lead to accidents. Statistics show that out of the accidents with heavy load vehicles involved the most severe cases are usually those with vulnerable road user(s) - pedestrians, cyclists, moped riders and motorcyclists in the blind spot of the truck.

Advanced Driver Assistance Systems (ADAS) aim to increase safety and comfort of driving by automating some of the driver's tasks. To support the driver in awareness of the situation in the blind spot area, prototypes of two ADAS systems were developed: Blind Spot Detection for urban scenarios and Passive Lane Change Assist for the highway application.

The Blind Spot Detection system aims to increase traffic safety by informing the driver about moving object(s) in the close proximity to the truck and activating the brakes if imminent collision with the object is predicted. The Passive Lane Change Assist system is meant to be used on the highway. It monitors the lane at the right side of the truck with trailer and informs the driver about other vehicle(s) driving in the close proximity to the truck.

Challenges

The main challenge of the project was to upgrade an automated driving system with safety functionality. To tackle this challenge several aspects have to be considered such as functional safety, operational safety and system engineering methodology. An additional challenge was to incorporate fail-safety and fault-tolerance in the developed solution.

Results

The project resulted in a validated design at both simulation and real-vehicle level. The tests showed that the CAD system has improved safety in case of failures. It is presented that the CAD system can prevent a collision between the vehicles even in critical situations. Moreover, in case of non-critical situations the system reacted on a smooth way.

Benefits

TNO obtained a systematic approach as basis for further extension of the CAD safety functionality. Moreover, the proposed approach resulted in a modular design which is compatible with the functional safety ISO26262 standard. This is beneficial for TNO, because a functionally safe system can be tested in mixed traffic conditions.

Dimitrios Tzempetzis PDEng

Towards a safety concept for cooperative automated driving

"Dimitrios developed rapidly his knowledge on the project topic and easily found his way within TNO. His work resulted in two main contributions: First, a systematic approach towards a fail-safe design and second a solution that reduces the amount of possible collisions significantly. Moreover, the process of reaching this result was well organized by his planning and risk analysis."

Ellen van Nunen MSc
Research Scientist
TNO

Next to the production of Advanced Driving Assistance Systems (ADAS) the automotive companies focus on the development of automated driving solutions. In these solutions the driver cannot be considered to be backup of the vehicle. Therefore, significant effort is required for the advancement of the vehicle intelligence and particularly for the development of safety systems.

TNO aims to introduce truck platoons on highways in the following years. A truck platoon consists of two trucks which can drive cooperatively at less than 1 second time-distance. To achieve this, the Dutch research organization upgrades the Cooperative Automated Driving (CAD) system with safety functionality and performs extensive testing. In this context, TNO initiated the safety concept project for the CAD system.

The project focused on the approach for the safety concept development of the CAD system. The approach incorporates the system engineering methodology and the functional safety ISO26262 standard guidelines. Moreover, the approach was applied to the CAD system in order to upgrade its safety in case of failures.

Challenges

The biggest challenges of the project were: the arrangement of the cooperation mechanism within the supporting companies, suppliers, and university; and the preservation of a constant communication between the stakeholders.

Results

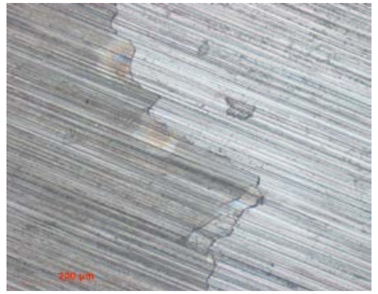
The measurement system was designed, implemented and tested using a specifically modified tribometer setup. The setup allowed the verification and the validation of both sensor technologies to measure the oil-film thickness. The project also created the fundaments to further develop the system into a complete integrated test bench.

Benefits

The benefit of this project is to implement the designed system in a fully-functional test bench to evaluate the performances of Bosch's push-belts. Hence, allowing the design engineers in Bosch to acquire additional knowledge on the push-belts behavior, and develop their products to match customers' requirements.

Stefano Vignati PDEng

Development of Measurement Methods for Squeeze Effect in Element-Pulley Contact



"Stefano's work in the development of the measurement system gave us a lot of insight in the more fundamental challenges of this task. Although the system is not yet integrated, he delivered the necessary solid base to reach this challenging target. We appreciate him as an eager person and valuable colleague."

Walter Goorts
Bosch Transmission Technology

Bosch Transmission Technology develops the push-belt, the heart of the Continuously Variable Transmission (CVT). The push-belt runs between two variable distance pulleys, those three components consist in the variator. In the variator the torque is transferred by one pulley to the push-belt by frictional force between the sides (flanks) of the belt and the pulley sheaves. This frictional force should be as high as possible, with an acceptable degree of wear. To maximize this force, and therefore increase the overall CVT efficiency, it is necessary to understand the role of each physical phenomena in this contact.

This project describes the design process of a measurement system to detect the squeeze effect in the element- pulley contact. The proposed system aim's is to measure the contact parameters, and explain how the lubrication varies during the contacting period.

The complete measurement system presented in this work is designed to be suitable for two sensing methods, namely: measuring the distance between the pulley surface and the push-belt elements, using non-contact displacement sensors; or measuring the contact pressure, using thin-film strain-gauges. Although the technical disparities, the main difference between the two solutions is that non-contact displacement sensors were acquired and built on the setup; whilst thin-film strain-gauges were created in the laboratory using Physical Vapor Deposition (PVD) process.

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