PDENG PROJECTS 2018

Automotive/Mechatronic Systems Design

TU/e

EINDHOVEN UNIVERSITY OF TECHNOLOGY

The PDEng Automotive Systems Design is an accredited and challenging two-year doctorate-level engineering degree program. Since 2015 the subtrack Mechatronic Systems Design is part of this program. During these programs 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 and mechatronic systems. In particular, there is a focus on the multidisciplinary design aspects of project-based research and engineering in high-tech automotive and mechatronic systems, reflected in the key contributions by four TU/e departments. For more information please visit tue.nl/asd.

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PROF.DR. H. NIJMEIJER
DR. P.S.C. HEUBERGER

The 2018 generation ASD/MSD trainees

In 2018 we celebrated the graduation of 14 trainees of the PDEng programs ASD (7) and MSD (7), bringing the number of alumni of these programs to 64. After the start of the ASD program in 2011, motivated by the demand of the automotive industry for system architects and designers, an additional track, MSD, was started in 2015 with strong support of the TU/e High Tech Systems Center. Both programs are driven by the rapid changes in the Dutch high-tech ecosystem with huge challenges in terms of multidisciplinary product and process design and engineering. These two-year post-master programs educate their trainees in-depth in various automotive and mechatronic related disciplines, as well as in personal and professional development.

This variation in disciplines is reflected in the 14 projects that are presented in this booklet. The subjects of these projects are in the areas of Mechanical Engineering and Design, 3-D printing, Advanced Driver Assistance Systems (ADAS), Electric and Diesel Engines, Transmission Systems, Modelling of Buses for energy saving and smart transport solutions, Monitoring and Harvesting for agricultural applications, and Medical Robotics.
Two ADAS projects focus on the extension of advanced cruise control and lateral control systems by making use of predictive map information.

3-D printing, or Additive Manufacturing (AM), is becoming more and more important. Two projects deal with the control of AM systems, to support more automated production.

The next decade will witness an enormous growth in Electric mobility. Two projects deal with this subject, one with thermal modelling of electric buses, the second with electrified transmission systems. Related to the latter are two projects on powertrain optimization. One of these deals with the development of a tool to design transmissions in an optimal way. The second project concerns optimal design of an hybrid electric powertrain. Another project deals with the development of a smart electric bus system, in areas where train transport cannot be realized.

For long-haul heavy duty trucks the use of diesel engines will stay important for a longer period. One project focusses on the use of a single cylinder research engine for the exploration of new high-efficient and low-NOx combustion regimes.

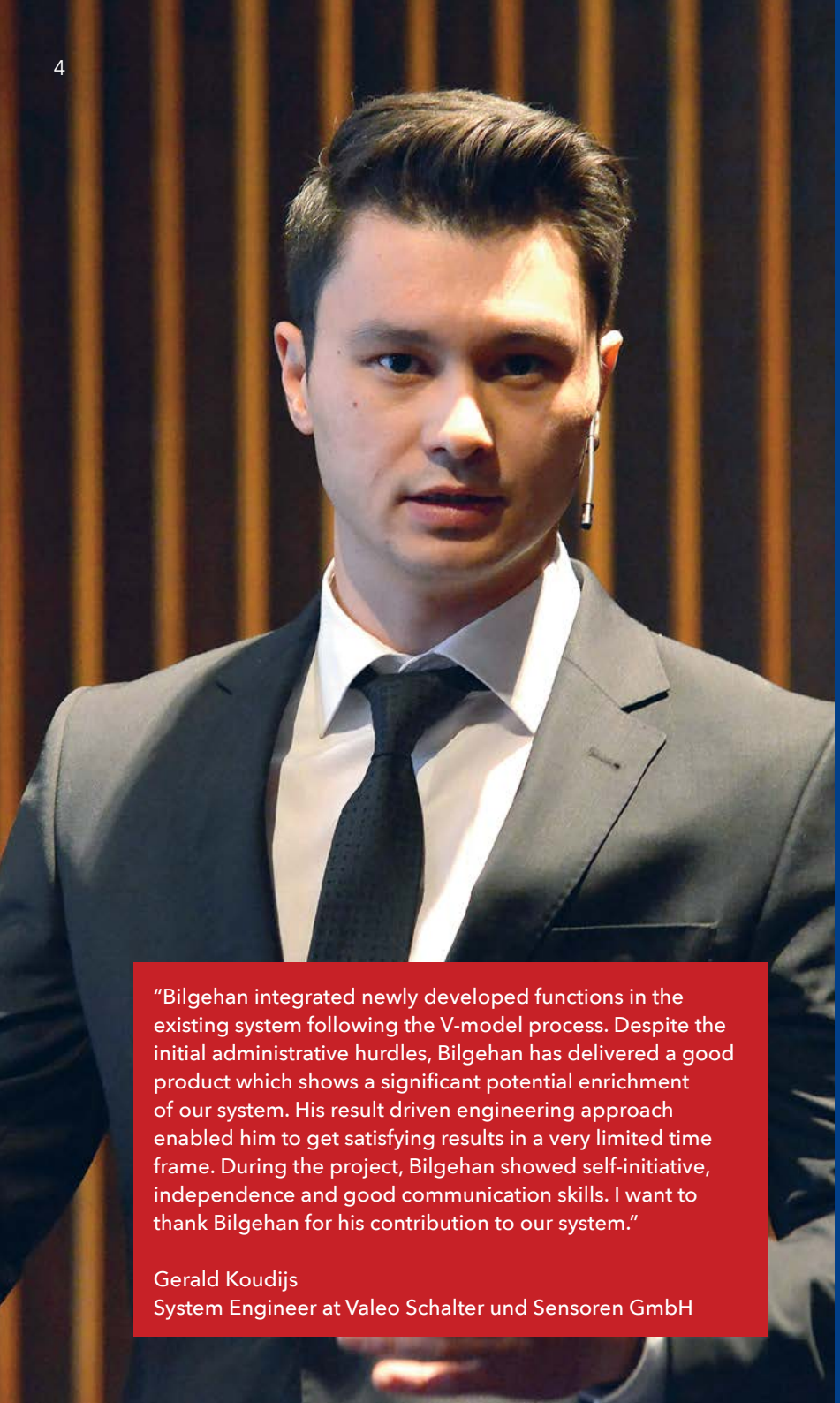
The agricultural sector is rapidly adopting high-tech innovations and applications. One project deals with a machine to harvest asparagus, in particular the replacement of an electromechanical subsystem by a hydraulic actuator. A second project in this area concerns the poultry industry, where a vision system is developed to automate the process of egg inspection and selection. A third application deals with the design of a machine to process poultry meat, in particular the subsystem to remove the wishbone of chickens.

The use of high-tech technology in medical applications has proven to be of high value. The last project focusses on a mechatronic solution to improve the treatment of a serious eye disease in prematurely born children, especially occurring in large numbers in third world countries.

These final PDEng projects, proposed and paid 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.

Henk Nijmeijer
Scientific Director

Peter Heuberger
Program Manager



"Bilgehan integrated newly developed functions in the existing system following the V-model process. Despite the initial administrative hurdles, Bilgehan has delivered a good product which shows a significant potential enrichment of our system. His result driven engineering approach enabled him to get satisfying results in a very limited time frame. During the project, Bilgehan showed self-initiative, independence and good communication skills. I want to thank Bilgehan for his contribution to our system."

Gerald Koudijs
System Engineer at Valeo Schalter und Sensoren GmbH

CHALLENGES

The main challenge for this project was to prepare and work on a digital map framework that is new to both Valeo and TU/e. Another challenge was to work on a platform that is already developed and to integrate new functionalities in it modularly.

RESULTS

The proof-of-concept implementation of the A-ACC system was successful. The developed system was validated using Rapid Control Prototyping (RPC) on a vehicle. The test results showed significant potential enrichment in the functionality of the existing system.

BENEFITS

Valeo gained insights into the map-enabled ADAS functions. The developed functions along with the system architecting work can be integrated and used in other automated driving platforms.

BILGEHAN BAYAR, MSc PDEng

Advanced Adaptive Cruise Control System

DEVELOPMENT AND VALIDATION OF AN ADVANCED ACC SYSTEM USING ADASRP

In recent years, one of the primary goals and concerns of the automotive field is to increase the road safety and comfort levels for the road users. Automated and fully autonomous driving is foreseen as the most prominent solution in order to achieve these goals. Valeo is a global automotive supplier with a business group focusing on the Comfort and Driving Assistance Systems. In the area of high-speed driving solutions, Valeo offers longitudinal control functions such as the Adaptive Cruise Control (ACC) system.

In the pursuit of automated driving, a company like Valeo is always in search of developing and advancing such systems. One way to extend the functionality and availability of the current automated system is adding new inputs to the system. For this reason, Valeo aims to use a digital map as a new source of information to the system. Accordingly, Valeo targets to bring the state of the art map functions to their ACC system with this project.
On the basis of this target, the context of this project is to develop and validate an Advanced Adaptive Cruise Control system using ADASRP.

CHALLENGES

One of the main challenges of this project was to develop and integrate the A-LC functionality into the existing system architecture, which is available in the Enterprise Architect tool. Another challenge was to prepare and work with the digital map framework that is new to both Valeo and TU/e.

RESULTS

The proof of concept is established by developing, building and integrating the A-LC system into a prototype vehicle. The project yields to a first step in achieving a robust lane change. It shows the confidence in using the digital map data to handle scenarios where the camera data is not reliable or has limitations.

BENEFITS

Valeo gained insights into the ADASRP framework, which can be used to enhance the high speed and low speed automated functions. The lane change functionality development along with the system architecting work can be used to further steer the development of the lateral control functions.

"Despite some legal interference, as well as the challenging nature of the project itself, Sharad performed well in executing the project. He showed system engineering skills in understanding the project goals and retrieving use-cases and requirements. For the system architecture and lane change development, Sharad showed a good understanding of literature, controller and controller design. During testing Sharad showed both patience and capability to work in a team. Overall Sharad showed a high level in persistence towards achieving the projects goals."

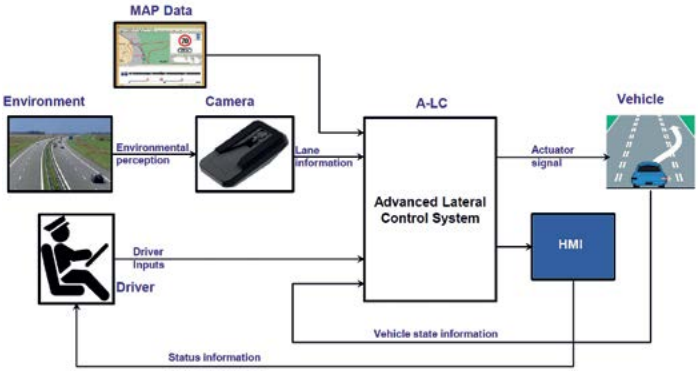
Dr. Fabian Fuchs,
Software Design Engineer at Valeo Schalter und Sensoren GmbH, Bietigheim-Bissingen

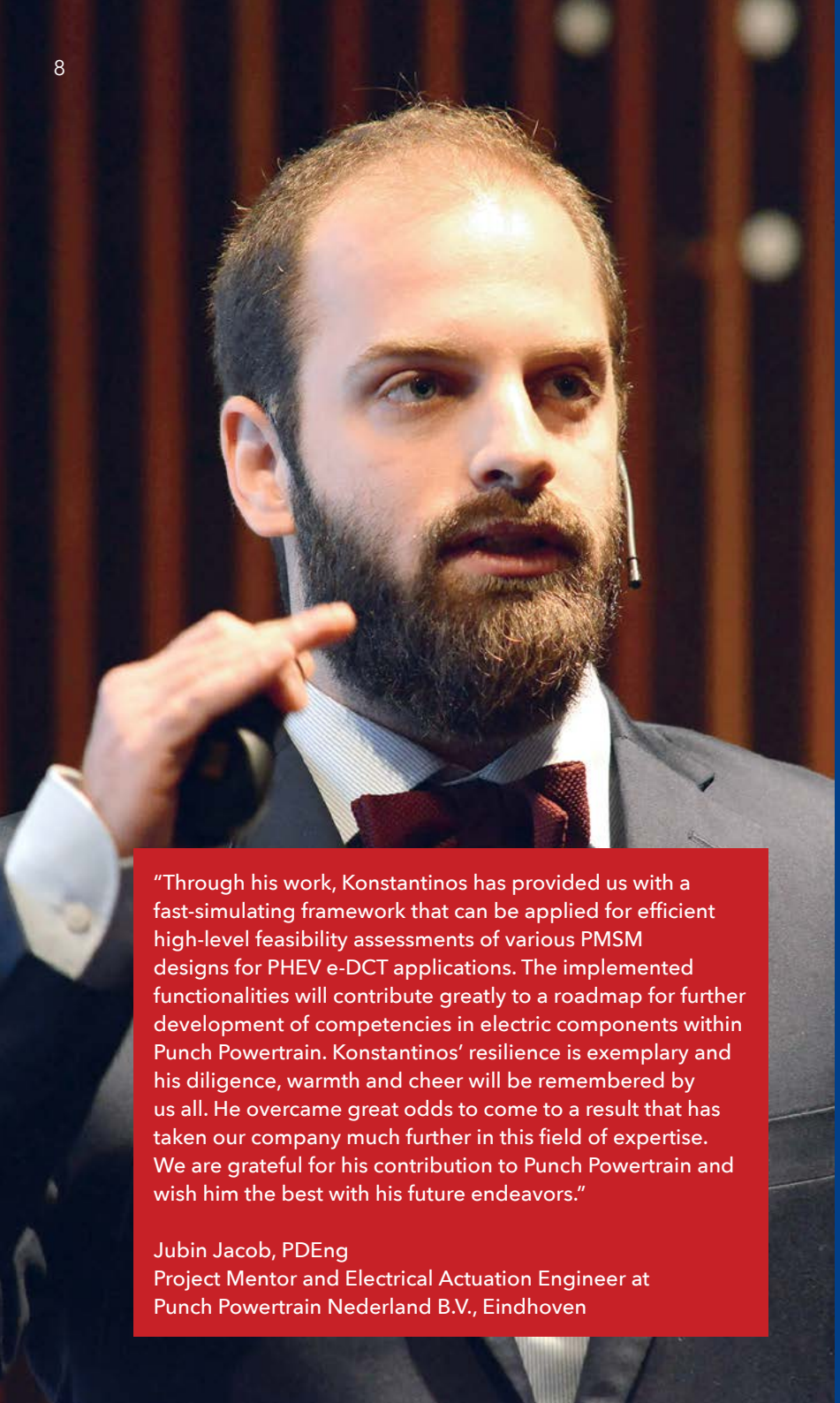
SHARAD BHADGAONKAR, MSc PDEng

Advanced Lateral Control System

In recent years, one of the primary goals and concerns of the automotive field is to increase the road safety and comfort levels for the road users. Automated and fully autonomous driving is foreseen as the most prominent solution to achieve these goals. Valeo Schalter und Sensoren GmbH is a global automotive supplier focusing on the Comfort and Driving Assistance System. In the area of high-speed driving, Valeo offers a camera-based lateral control system focusing on the lane centering.

For automated driving, one of the core and vital maneuvers is a lane change. With this project, Valeo aims to add the lane change function to their existing range of lateral control functions. Along with it, Valeo desires to bring the state-of-the-art to these functions with the help of digital map data known as ADASRP. ADASRP extends the immediate sensory horizon available and enables the drivers to anticipate the road ahead. Hence, Valeo aims to improve the performance of the lateral control systems using the digital map information. In this context, the project was defined to design an advanced lateral control (A-LC) system. The primary objective was to design a lane change system and to use ADASRP for handling the special lane centering scenarios.





"Through his work, Konstantinos has provided us with a fast-simulating framework that can be applied for efficient high-level feasibility assessments of various PMSM designs for PHEV e-DCT applications. The implemented functionalities will contribute greatly to a roadmap for further development of competencies in electric components within Punch Powertrain. Konstantinos' resilience is exemplary and his diligence, warmth and cheer will be remembered by us all. He overcame great odds to come to a result that has taken our company much further in this field of expertise. We are grateful for his contribution to Punch Powertrain and wish him the best with his future endeavors."

Jubin Jacob, PDEng
Project Mentor and Electrical Actuation Engineer at Punch Powertrain Nederland B.V., Eindhoven

CHALLENGES

Machine design is an art which requires a careful iterative approach, and is especially compounded by the pursuit of the ambitious requirements dictated by the automotive industry. In this regard, the main challenge of this project was the lack of expert guidance in such a complex and multidomain topic, like the one of electric machine design. An additional challenge was the dynamic stakeholder environment and the frequent change of priorities.

RESULTS

An architecture framework for analyzing the feasibility of a PMSM drive system was designed and implemented. This framework enables the investigation of a design space and the identification of machine designs that fulfill certain requirements. Furthermore, the key-design parameters of a PMSM and inverter were identified, and their interdependencies were highlighted. Finally, based on a set of specifications, a 4-step methodology for the design of a PMSM was proposed.

BENEFITS

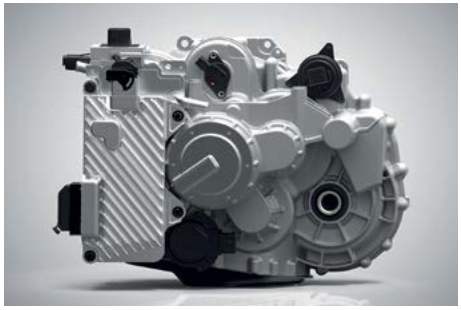
Through this project Punch Powertrain acquired a solid body of knowledge on various machine design parameters, which serves as a reference for future concept design efforts within the company. Furthermore, Punch Powertrain obtained a fast-simulating framework that can be applied for efficient high-level feasibility assessments of various PMSM designs for PHEV e-DCT applications. These functionalities contribute to a roadmap for further development of competencies in electric components in the broader Punch organization.

KONSTANTINOS-ALEXANDROS FRAGKAKIS, MEng PDEng

Framework development for the feasibility assessment of a PMSM drive system

A PHEV CASE STUDY

Punch Powertrain is an independent full system supplier of fuel-efficient powertrains, with over 40 years of experience in the production of Continuously Variable Transmissions (CVTs) and Dual Clutch Transmissions (DCTs). To keep pace with the increasing trend of electrification in the automotive industry, as well as respond to the growing market interests, Punch Powertrain is currently developing innovative electrified transmissions for Plug-in Hybrid (PHEVs) and Electric Vehicles (EVs).



The scope of this project has been limited to an electrified DCT (e-DCT) for PHEVs, which is a variant of the aforementioned transmissions. Moreover, the project is carried out at the Systems Engineering (SE) department of the company, which is responsible for defining the architecture of the electrified transmissions, setting requirements for the different components, and assuring that verification and validation is done on the system level. The expertise within Punch Powertrain exists on the mechanical development, but is not yet established in the domain of electric components. Therefore, their design and development are currently outsourced. To enhance the knowledge in the SE department on the design and impact of the electric components on the transmission, this project was initiated.

The main goal of the project is to establish a framework that can be applied for efficient high-level feasibility assessments of various PMSM designs for PHEV e-DCT applications. The reason behind the development of such a framework is the need for compliancy response methods and tools towards prospective clients of the company.

CHALLENGES

The initial challenge of the project was to obtain system-level parameters of a hybrid powertrain whose design parameters and system behavior can cover different usage conditions in the best possible way. Moreover, the coupling between the control and design parameters of hybrid powertrains transforms the problem into a co-design problem. Increasing robustness while enhancing the computation time as two conflicting objectives was the main challenge of the project.

RESULTS

Two novel methods for cycle time reduction while yielding robust optimal parameters are proposed. Applying the methods on the hybrid powertrain co-design results in significant reduction of computation time up to 93% with a trivial compromise on robustness.

BENEFITS

The two proposed methods are practical to use for optimization of powertrains in industry, offering remarkable enhancement in computation time and robustness to the cycle variation. The industrial partners can now apply this technology on industrial use cases, in order to investigate how generally applicable these methods are, not only on vehicle powertrains but also on machine powertrains.

"Farzad conceived two novel methods for taking into account the effect of a set of system usages on the robustness of a mechatronic system design. Thanks to this project, we now have techniques in hand that allow to select a limited set of drive cycles from a large set of drive cycles or that allow to generate an artificial driving cycle. Both methods lead to a quantifiable robust result for the optimization objective and for the design and control parameters."

Jan Stroobants
Senior Research Engineer, Flanders Make

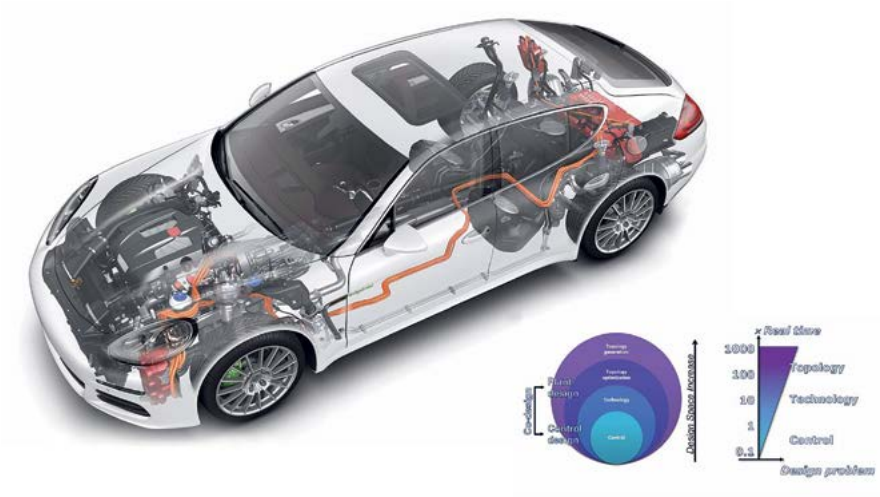
FARZAD MOBINI, MSc PDEng

Robust Optimization for System-Level Design in Mechatronic Systems

DRIVING CYCLE SYNTHESIS FOR OPTIMAL DESIGN OF HYBRID ELECTRIC POWERTRAIN WITH ROBUSTNESS TO DRIVING CYCLE VARIATION

With the evolution of technology, engineering design shifts focus from feasibility to optimality. Modern mechatronic design methods should enable the concurrent optimal design of various components from different domains. Currently, system-level design consists of linking several independently optimized sub-systems. However, on a system level, this does not necessarily lead to an optimal design and behavior. In order to meet these modern design challenges in the mechatronic industry, effective system-level design optimization techniques are required which can manage physical and control parameters while taking the dynamic behavior of the machine into account.

The goal of this research is to come up with methodologies to enable obtaining control and design parameters of a hybrid powertrain resulting in near-optimal behavior for different scenarios rather than a specific scenario. Increasing robustness while enhancing the computation time as two conflicting objectives of this research call for methodologies which allow for reducing driving cycle time while yielding robust optimal parameters in the optimization.



"Davide's assignment involved the design of architecture for the thermal management system and the development of a multi-zone thermal and air quality model of the bus cabin. The developed model is well structured and the process is repeatable to new buses. Davide has made a good effort in making the process as much automated as possible and developed a user friendly interface, which is valuable to the company."

Roshni Digumoorthi,
Energy Management Specialist @ VDL ETS
Energy Management Team, Concept Development Department

CHALLENGES

Thermal and air quality dynamics are non-linear 3D phenomena, with many disturbances. The main challenge was to define a methodology that allows to model accurately such complex dynamics and at the same time is simple and fast enough to be used for control development.

RESULTS

The outcomes of this project are a Thermal Management System (TMS) architecture and the thermal and air quality models of a VDL e-bus cabin. The TMS system architecture is a useful input for future projects in the domain of energy management. The thermal and air quality models are functions of the TMS, that aim to estimate the energy consumption of the e-bus heating and ventilation system.

BENEFITS

The developed software is several times faster than real-time and accurate enough for energy consumption estimation and control system development. The applications of this software can provide a competitive advantage to VDL e-buses in the future, both in terms of performance predictability and in terms of energy consumption.

DAVIDE OCCELLO, MSc PDEng

E-bus Multi-zone Thermal Management System Design

Battery capacity and cost are a decisive factor for the competitiveness of e-buses when compared to traditional diesel buses. In order to reduce cost, battery size is typically minimized. This limited battery capacity is challenged even more during winter months when buses need to be heated to provide a comfortable environment for the passengers & the driver. With the current technology, up to 60% of the total range of the electric buses that operate in the region of Eindhoven (NL), can be lost during extremely cold days.
The result of such a variability in range is that fleet operators need to introduce buffers & redundancies in the scheduling, thus increasing planning complexity & operation costs. On the road to increase its competitiveness, VDL is developing energy management systems that aim to reduce the energy consumption of its e-buses.
This project contributed to this goal by designing a Thermal Management System architecture and modelling useful system dynamics which will aid the development of the energy-saving strategies of the future.

CHALLENGES

Strict technical limitations on the system specifications (geometrical space, weight, cost, speed, available hydraulic flow and power etc.) impose a lot of restrictions and demanding requirements for the subsystem. Additionally, the uncertainties on the working conditions of the unit and relatively high performance expectations create challenges for validation and testing of the system. Future implementation of the built subsystem to the main machine may require some essential changes in the design of the main machine.

RESULTS

At the end of the project, the developed subsystem is tested under realistic conditions and the test results showed that the solution is very promising for high performance and applicability. The prototype system proved that even in case of some limitations on the hydraulic flow, still, the system can perform better than the electromechanical equivalent.

BENEFITS

The developed system directly generates the desired linear motion output without using any transmission. This reduces the required number of components significantly and increases the robustness. Additionally, since there are no power conversions, the overall efficiency in the system increases. This project also makes further cost reduction for the Z-axis possible, because different than the electromechanical alternatives, it directly uses the available hydraulic power and does not require any expensive power electronics or driver circuitry.

"Starting from scratch Tuncay managed to design and realize a working prototype with the required performance. For Cerescon B.V., this opens up a promising technology that was beyond our grasp, within the regular project approach of development activities in the company. For that we are grateful and we appreciate the efforts that were required and delivered. It is not easy to realize such a project and overcome all practical issues within a limited time frame, especially on your own with limited experience in some of the required skills."

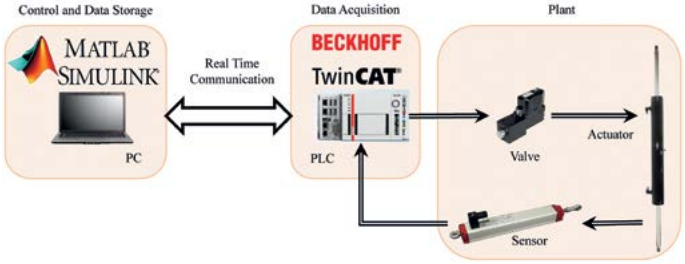
ir. Ad Vermeer
Managing Director / CTO of Cerescon

TUNCAY UĞURLU ÖLÇER, MSc PDEng

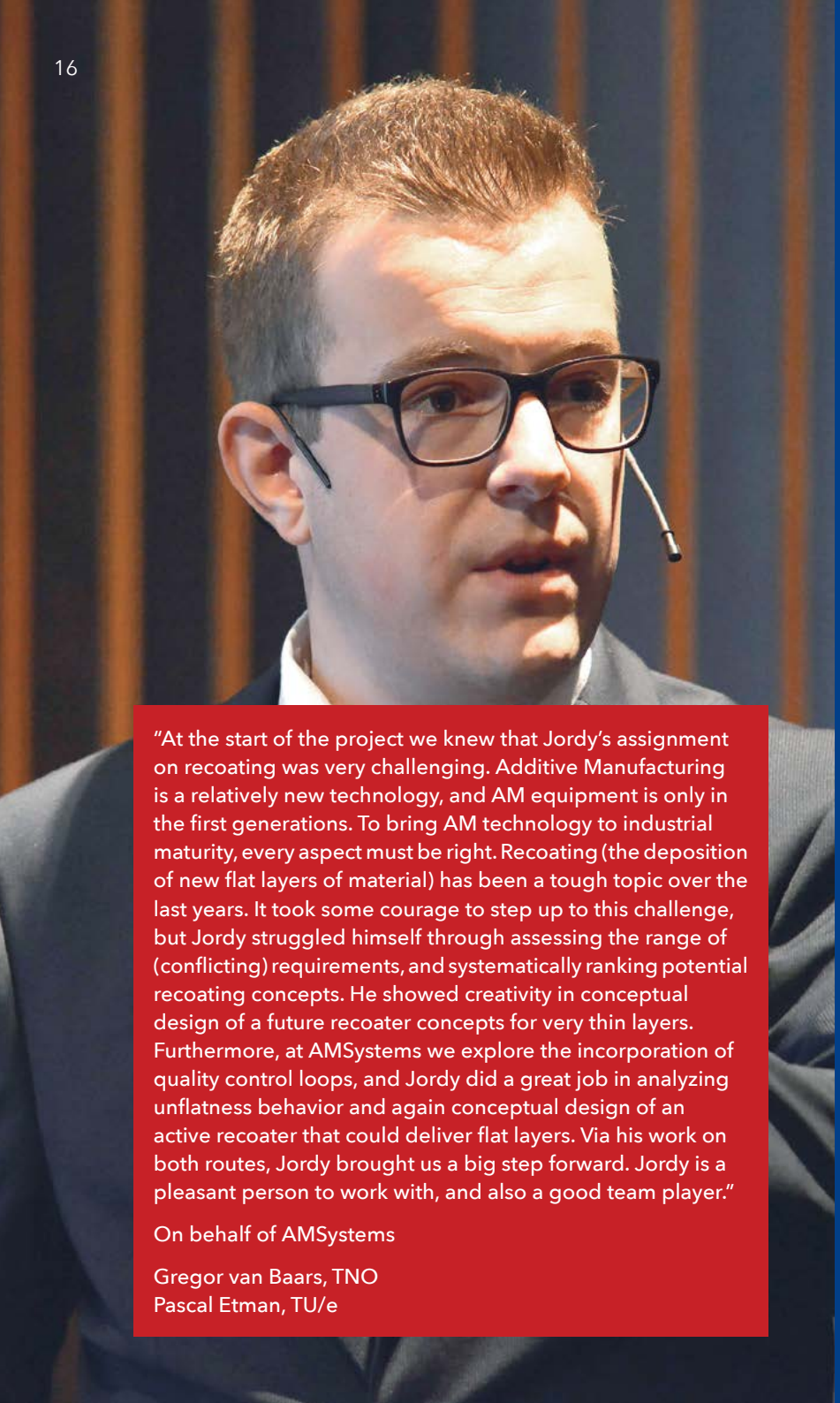
Building a Hydraulic Z-Drive for an Asparagus Harvesting Machine

Mechatronics technology is a rapidly growing technological area that has applications in almost every part of modern life. As an innovative start-up company, Cerescon B.V. focuses on the development, production and marketing of an automatic selective asparagus harvesting machine for white asparagus to increase the profitability and efficiency of the agriculture business while decreasing the required workload and human effort, by connecting mechatronics with the farmland.

In that project, the mechatronics knowledge is applied to a subsystem of an asparagus harvesting machine that is towed by a tractor. The machine detects the underground asparagus sprouts while in motion and harvests them via a Cartesian picking robot on X-Y-Z directions to which a cutter knife head is attached.



In the current machine, all those 3 axes are actuated by electromechanical subsystems. The Z-axis (vertical) direction subsystem is penetrating into the soil bed. During that penetration, some excessive opposing forces occur because of the uncertain structure of the soil. Due to some limitations in the power and speed capabilities of the current electromechanical subsystem, some restrictions in the motion may arise. To overcome these restrictions, the available hydraulic power supply from the towing tractor can be quite effective and beneficial. In that manner, a servo controlled hydraulically actuated system is considered to be an alternative solution via bringing together the robustness and force density of hydraulics and flexibility of servo controls. In this project, a servo controlled hydraulic subsystem has been developed starting from scratch and validated on prototype level.



"At the start of the project we knew that Jordy's assignment on recoating was very challenging. Additive Manufacturing is a relatively new technology, and AM equipment is only in the first generations. To bring AM technology to industrial maturity, every aspect must be right. Recoating (the deposition of new flat layers of material) has been a tough topic over the last years. It took some courage to step up to this challenge, but Jordy struggled himself through assessing the range of (conflicting) requirements, and systematically ranking potential recoating concepts. He showed creativity in conceptual design of a future recoater concepts for very thin layers. Furthermore, at AMSystems we explore the incorporation of quality control loops, and Jordy did a great job in analyzing unflatness behavior and again conceptual design of an active recoater that could deliver flat layers. Via his work on both routes, Jordy brought us a big step forward. Jordy is a pleasant person to work with, and also a good team player."

On behalf of AMSystems

Gregor van Baars, TNO
Pascal Etman, TU/e

CHALLENGES

One big challenge was coping with the different opinions within the AMSYSTEMS Center about the recoater system, not everybody is convinced the current implementation is the correct one. I tried to come up with a systematic approach to test the current system against other possible recoating systems. Another challenge was the lack of a good model and sensor. It is difficult to make design choices without understanding the physics behind the problem.

RESULTS

I introduced a Systems Engineering method to compare concepts and to pick the best concept based on the set of requirements. Some conceptual drawings of an alternative recoater system were made, based on this method. Next to this, a 3D design of a new controllable recoater, based on the existing implementation, was created.

BENEFITS

This project gives AMSYSTEMS Center insight in which direction to go to with the Lepus machine. If they want to stick close to the existing system, they can implement the proposed controllable recoater. Or they can decide to reevaluate the current system. In this case they can choose to start from the concepts that resulted from the Systems Engineering approach, or use the approach itself to come up with new concepts.

JORDY SENDEN, MSc PDEng

Design of a Recoater Concept for Additive Manufacturing of Ceramics

AMSYSTEMS Center has developed the Lepus Next Gen, a prototype AM system based on stereo-lithography. It can be used to print with pure photosensitive polymer resins as well as with resins mixed with ceramics particles. This allows for printing of ceramic green parts, which can be sintered in an oven to obtain the final ceramic product. The aim for the Lepus system is to ensure product quality through feedback control on the layer level.

This research focused on the actuation side of the control loop. The main goal was to create a recoater concept to minimize the layer errors. Two directions are explored to reach this goal. The first direction started from the existing system and suggests adaptations to enable control. A flow model was created and validated, which served as a basis for the changes to the current system. For the second direction a Systems Engineering approach was taken to come up with a better alternative to the existing system. To this end an extensive requirements analysis was done and a functional decomposition of the printing process was made. A choice was made on the implementation of each sub-function, such that all requirements would be met. This approach suggested that a constrained surface system would perform better at creating thin and flat layers than the current system.

CHALLENGES

Punch Powertrain is developing innovative next-generation hybrid transmission, based on dual clutch technology. During the design process of such a complex system, finding the optimal design solution is a trade-off between many system parameters, like transmission component sizes and control strategies. In order to make this trade-off easier, a framework is needed to facilitate the decision making process.

RESULTS

A generic optimization framework capable of handling powertrain optimization problems and doing sensitivity analysis of powertrain parameters was developed for Punch Powertrain. The framework includes transmission and vehicle models as well as optimization algorithms that can be used for sensitivity analysis and optimization of the transmission hardware design, the transmission control algorithms or both simultaneously.

BENEFITS

The optimization framework developed in this project is a user-friendly design tool which can be used in evaluating hybrid drive strategies and component choices while designing hybrid transmissions at Punch Powertrain. The modularity of the framework allows a system designer to tackle any kind of powertrain optimization problem with different kinds of optimization algorithms available as a choice.

"During the design process of a hybrid transmission, finding the optimal design solution is a trade-off between many system parameters. In order to make this trade-off easier, an optimization framework was developed by Anshuman within the System Engineering team. From the very beginning of the project, Anshuman has taken ownership of the assignment and he has been able to keep all stakeholders involved. His hard work and creativity have led to a generic user-friendly optimization framework that can be used for answering a wide range of design questions, which is extremely useful for the system engineering team in Punch Powertrain. We would like to thank Anshuman for his hard work, dedication and positive and friendly attitude during the project. "

ir. Thijs Purnot
Systems engineer at Punch Powertrain Nederland B.V., Eindhoven

ANSHUMAN SINGH, MSc PDEng

An optimization framework for hybrid transmissions

Punch Powertrain is a leading independent supplier of transmissions to the automotive industry. Punch provides a complete range of powertrain solutions for passenger car segments which includes conventional, hybrid and full electric solutions. To answer the needs of car manufacturers moving towards vehicle hybridization, Punch Powertrain Eindhoven is developing a new type of hybrid Dual Clutch Automatic Transmission.

The Systems Engineering department at Punch Powertrain is responsible for setting up requirements for hybrid transmission. The requirement setting process for the hybrid functions involves a careful trade-off between the reduction of fuel consumption, performance and comfort in driving and shifting. The process eventually leads to component choices but also to the definition of the targets and limits for control strategies that have to be implemented. In case of hybrid vehicles, there are numerous possibilities to operate the e-machine and combustion engine together in combination with the clutches and different gear ratios. The design choices made over these operating points and the choice of component parameters affects the overall drivability and vehicle performance.

The main result of this project is a MATLAB/ Simulink based optimization framework, which can be used by the SE department of Punch Powertrain, to evaluate hybrid drive strategies and define an approach to come to a balanced trade-off in design decisions for the hybrid transmission design.
This framework is intended to be used at system level during the hybrid transmission design process.

"The project conducted by Akarsh gives the Vencomatic Group a foundation for our vision system in implementing it as a management tool. The group is specialized in automation, and as such this machine was designed to save labor costs, however, Akarsh's work showed us that the information gained from the visual inspection of eggs can give valuable insights in the management of the birds in the stable. Despite several setbacks, Akarsh used data mining techniques and managed to make an advice generating tool. Knowing this is a new field for him personally and company as well, I admire the brave decision to dive into the project and keep searching for new angles to solve the problems at hand. We have a lot of work to do before we can scale this technology up, but when we are ready we hope to see Akarsh again."

Dick van de Ven
Product designer at the Vencomatic Group

CHALLENGES

Laying the foundations of data mining and analysis in the poultry industry. Gathering domain knowledge from poultry experts and veterinarians to deploy it in the form of algorithms that constitute machine intelligence.

RESULTS

The system can generate control advice based on the anomalies that are found in the logged data. With rich information, i.e., contextual data on environment, better diagnosis of probable causes can be made and thus, improving the confidence in the corrective actions advised.

BENEFITS

The farms can use the system to keep an overview of production and quality. Using the generated advice along with contextual information logged locally, they can make appropriate judgements on the correction action to take. With the completion of the project, Vencomatic Group B.V. is investing in developing infrastructure to collect data and set up a data science division at the company.

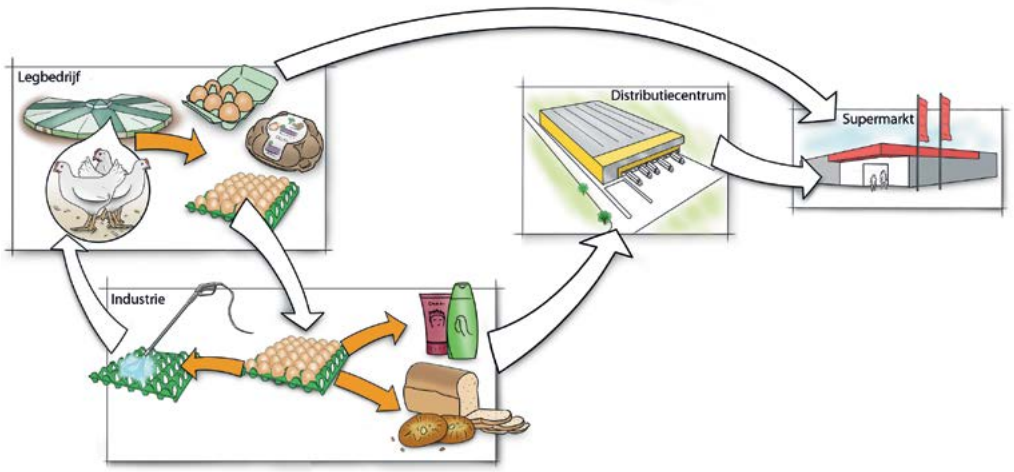
AKARSH SINHA, MSc PDEng

Use of data from Vision Systems as a management tool

FOUNDATIONS OF DATA ANALYSIS IN INSPECTING AND GRADING TABLE EGGS IN THE POULTRY INDUSTRY

In the poultry sector, the Prinzen B.V.'s equipment (a Vencomatic Group B.V. company) has enabled farmers to automate a large proportion of their work in grading and packaging the eggs. To further assist the farmers, the development of a vision-based egg examining and grading machine, called the *Vision System*, was started to automate the process of egg inspection and selection. This *Vision System* can distinguish between different anomalies on the eggshells.

This system is aimed at enabling the selection of eggs that are suitable for consumption and can be sold in supermarkets. Besides the egg selection process the information gained from the grading of eggs can be applied in a much wider context. Different anomalies on the egg give indications to different management challenges. To enable the farmer to optimize management of the flock, analysis on the data generated by the *Vision System* by deploying several data mining techniques can be used to report a change of trends in production and generate advice.



CHALLENGES

Single cylinder engines act as valuable tools to perform detailed performance studies and help in understanding various parameter influences on the combustion. While this provides a number of economic and technical advantages, the performance behavior, in terms of fuel consumption and emissions, seen on the single cylinder cannot be directly interpreted as the same on an equivalent multi cylinder engine.

RESULTS

In the context of this project work, a framework has been developed that enables the translation of the single cylinder results to equivalent multi-cylinder performance estimation. The developed framework provides a guideline on how to carry out tests on the single cylinder engine and the sequence of post processing steps needed to analyze the test results and translate them to an equivalent multi cylinder engine performance.

BENEFITS

A well-defined approach and a structured methodology has been realized in this work. This would enable using the single cylinder engine as a tool for testing and analysis for the standard engine development process within DAF.

"Akshay's challenging PDEng assignment was to come up with an overall method for SCE testing procedures towards real engine predictions which requires broad knowledge of all different engine sub-systems and their strong coupling. Additionally, the large data-sets produced, comprehensive modeling tools involved needed to be analyzed and adopted wherever necessary.
The outcome of the structured and hard work within the project, is a well-defined approach and method for SCRE testing and analysis, which will from now on be part of the standard engine development process within DAF."

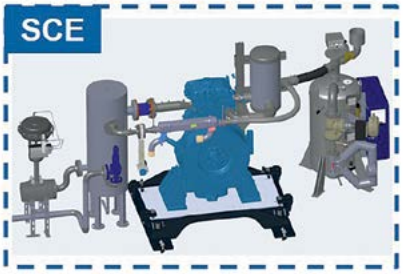
Maarten Meijer, DAF Trucks N.V

AKSHAY VAIDHIYANATHAN, MSc PDEng

SCE2MCE

FRAMEWORK TOWARDS MULTI CYLINDER ENGINE PERFORMANCE PREDICTION

Heavy-duty diesel engine vehicles have been the primary choice in the area of long distance road transportation over the years owing to the wide operating range of the vehicles, with high power and load capability, while maintaining high fuel efficiency. However, this advantage is achieved at the expense of NOx and soot emission as a result of combustion, making them one of the significant contributors to air pollution. Hence, the necessity for developing environment friendly internal combustion engines is on the rise with increasingly stringent emission regulations with equal focus on improving fuel efficiency.



For the choice and development of the optimal combustion system of the engine, detailed performance testing on the engine is necessary. This involves testing of different injection equipment, turbocharger unit, piston bowls, etc. to find the most fuel efficient system which also produces lesser emissions. Conventionally, these hardware tests are performed on the multi-cylinder engines. Since a large number of hardware variations are tested in these tests, it makes the development process time consuming and expensive.

The addition of a state-of-the-art Single Cylinder Research Engine (SCE) to the engine development process at the DAF engine test center, will facilitate the exploration of new high-efficient and low-NOx combustion regimes. The single cylinder engine offers a wide range of flexibility in terms of better understanding of the effect on individual parameter changes over the engine performance and the need for lesser hardware components compared to multi-cylinder engine, making the testing process more economical. However, a method of translating the results from single cylinder measurements is necessary to estimate the multi-cylinder performance. Within this project, a framework has been developed that enables the translation of the single cylinder results to equivalent multi-cylinder performance estimation.

"At the start of the project we knew that Tim's project was not an easy one. Additive manufacturing is a relatively new technology, and AM equipment is only in the first generations. So, there is a lot of room for improvement, but the way to go is not very clear and rather uncertain. At AMSYSTEMS Center we believe that incorporation of quality control loops is one of those ways, and Tim did a great job in enabling the control implementation in terms of hardware and software. He showed great analytic skills in assessing the state of the prototype system, and defining new hardware and software architectures. He showed ambition, and practical hands-on drive to get things done which brought us a big step forward. Tim also has acted as a good team player, and clear communicator."

On behalf of AMSYSTEMS Center,

Gregor van Baars (TNO)
Pascal Etman (TU/e)

CHALLENGES

Initially, the Lepus Next Gen was controlled using seven different tools, built using seven different languages. To develop machine control software that is more extensible, maintainable and user-friendly, knowledge of all of these tools/languages is required. Moreover, to support the transition to one tool/language for the machine control, some adaptations to the hardware have to be made.

RESULTS

According to the newly developed architecture, both the hardware and software of the Lepus Next Gen are redesigned. The entire machine control is built in TwinCAT and contains an integrated Simulink model to create all the necessary freedom for the integration of control loops. Additionally, the preprocessing of a print job is accelerated by a factor 70 and is integrated in the software for the sake of user-friendliness.

BENEFITS

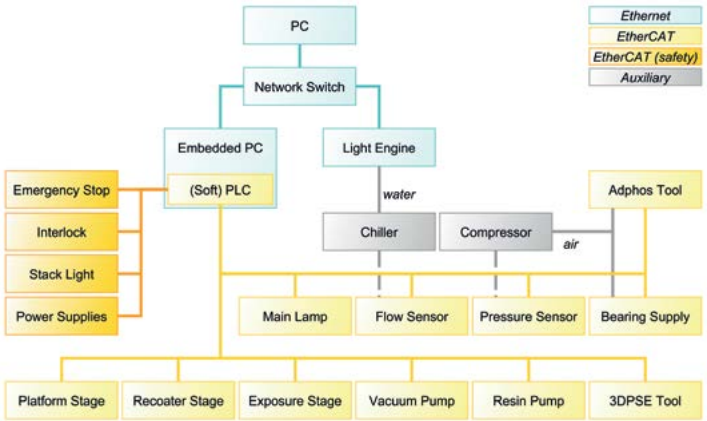
By replacing a part of the hardware modules in the Lepus Next Gen, the machine is suitable for real-time control and the integration of new modules, like sensors and actuators, has become much easier. Besides, using the new software platform it is pretty easy to apply changes to the print process, which ensures that this process can be optimized more easily.

TIM VERDONSCHOT, MSc PDEng

Development of the machine control architecture for an additive manufacturing system

Additive manufacturing (AM) encompasses the technologies to build 3D objects by sequentially adding material, usually layer-by-layer. This project focuses on stereolithography, which is an AM technology that has the potential to change the way of conventional subtractive manufacturing processes and to create entirely new production strategies.

To serve the high-tech industry's needs, AM equipment has to scale up to larger product sizes and higher product quality, motivating the integration of sensors and actuators for the application of closed-loop control in AM equipment. This leads to the main goal of the project, which is to design and develop the machine control architecture for the Lepus Next Gen such that actuators, sensors and feedback control loops can be incorporated in the machine. The Lepus Next Gen is a stereolithography-based AM system developed by the AMSYSTEMS Center.



The goal is achieved by partly replacing the hardware for the creation of an industrial computer network that is suitable for real-time distributed control. Furthermore, the machine control software is almost completely rebuilt from scratch and is designed and implemented in such a way that the vast majority of the code can be used as a basis for all other AM systems within the company.

CHALLENGES

To solve the problem of insufficient treatment opportunities of ROP, a mechatronic solution is needed to increase the treatment efficiency and to decrease the operation difficulties for ROP (Retinopathy of Prematurity) treatment.

RESULTS

A vision based automatic treatment concept is designed based on the ROP treatment requirements and customer wishes. And the designed concept is validated via experiments on a setup. The limiting factors to system performance are identified.

BENEFITS

A framework of this new prototype is preliminarily constructed. The central idea of the concept is proven such that more research and development can be implemented in the future based on the result of the project.

"Very few surgeons can perform high precision procedures to stop retinal bleeding in neonatal infants. As a result millions of babies who need these procedures but do not have access to care at the right time, go blind. Sa's work on precision control of laser systems to position beams for retinal ablations shows how rapid prototyping can be used to build demonstrators for complex medical applications like Retinopathy of Prematurity."

Anupam Nayak
Founder & COO Eindhoven Medical Robotics

SA WANG, MSc PDEng

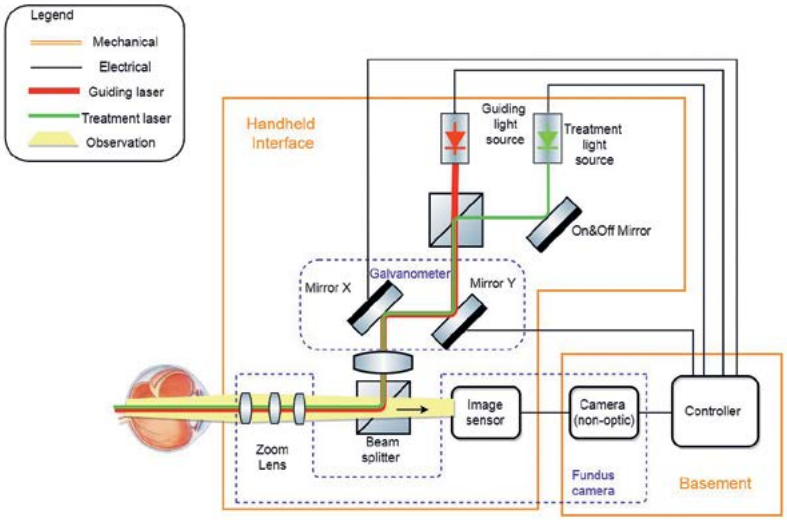
Neocure

A MECHATRONIC SOLUTION FOR ROP (RETINOPATHY OF PREMATURITY) TREATMENT

Retinopathy of prematurity (ROP) is a disease of the eye affecting prematurely born babies generally having received intensive neonatal care, in which oxygen therapy is used due to the premature development of their lungs. It is thought to be caused by abnormal growth of retinal blood vessels which may result in scarring and retinal detachment. ROP can be mild and may resolve spontaneously, but it may lead to blindness in serious cases.

The main option of ROP treatment is the laser photocoagulation method, which uses an Argon or Diode laser to photocoagulate avascular areas of retina. In regions with high rate of pre-matures, the number of surgeons who can do laser coagulation is insufficient to get every patient treated in time. This leads to the situation that babies not getting treated in time will be blind for the rest of their lives.

The motivation of this project is to come up with a mechatronic solution to improve the severe situation of some countries. The goal of the project is to design a system level concept of ROP treatment and to validate the concept with hardware.



"Joep provided a sound basis for a new concept of the wishbone removal module. During the in depth dialogues in the last months Joep showed creativity in playing with theory, explaining it with metaphors, and translating it to various concepts. The result seems very promising. The first version of this new module has an open character due to a huge decrease in number of components. If it is up to me, this concept will be used as a basis for other modules in the filleting system as well."

Laurens Philippo, design engineer at Marel Poultry

CHALLENGES

One of the main process-related challenges in this project was managing the different stakeholders and their expectations. The main technical challenge was related to the nature of the project: A complete redesign of the module. This required a good system overview and a clear understanding of its place within the processing line.

RESULTS

The proposed mechanism successfully combines two of the three motions found in the current system. This reduces the number of components, the moving mass, the cost and the complexity of the machine, besides offering more freedom in the processing itself. The proposed electronic coupling has shown to be able to handle the required higher throughput by using the "flying saw" principle.

BENEFITS

Marel intends to continue the development of the proposed concept. This could lead to a significant increase in throughput and would make the module future proof for a long time. Furthermore, the proposed electronic coupling could be used on other modules within the same line as well, leading to potential cost savings for that line as well.

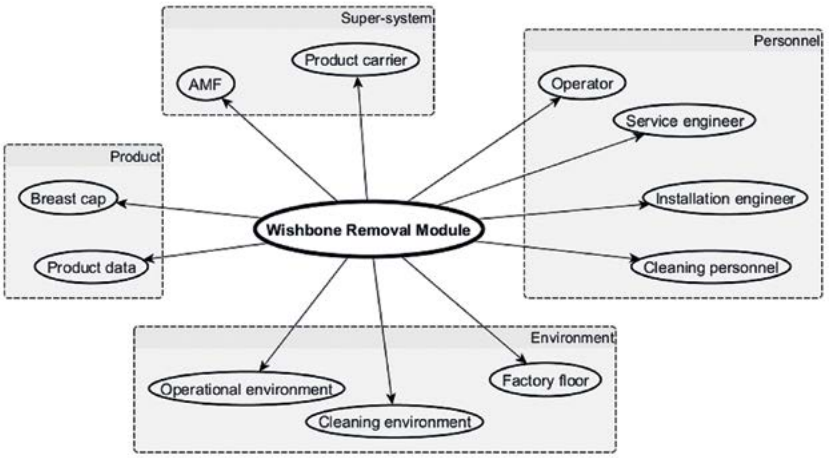
JOEP WOLKEN, MSc PDEng

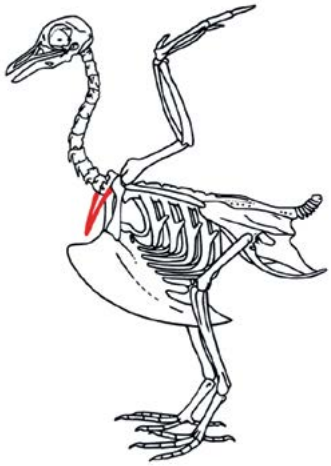
Conceptual Design of a Mechatronic Wishbone Removal Module

To solidify its position as global market leader in the development and production of poultry processing installations, Marel annually spends 6-7% of its total revenue on R&D. The current R&D philosophy revolves around replacing the predominantly mechanical machines by smarter mechatronic solutions.

One of those highly mechanical machines is the wishbone removal module. Since the machine's mechanical design is running against its limits, a new concept was required. This new concept should be able to handle roughly twice as many products per hour.

Using Systems Engineering tools as a foundation a new mechatronic concept was proposed, which demonstrated being able to handle the higher throughput in a test setup. This was achieved by replacing the mechanical coupling to the product conveyor and replacing it with an electronic one, allowing the use of the "flying saw" principle. Furthermore, a mechanism was proposed that combines two of the existing motions, reducing the number of components and the cost of the machine.





CHALLENGES

The two main challenges of this project were the complexity and extensive scope of the project. Numerous feasibility concerns needed to be researched, which were influenced by many design criteria, e.g., seating capacities, infrastructure design, vehicle design, passenger comfort, operating frequencies, vehicle maneuverability & stability, and the road vehicle legislation. The other challenge was the absence of the relevant model parameters. Therefore, assumptions needed to be made for the system and vehicle parameters.

RESULTS

The project results include energy consumption, costs, and vehicle dynamics models derived in a MATLAB/Simulink environment. These models were used to compare different system concepts after which a proposal was derived for the Smart Bus system. The proposed system is defined as a high-speed intercity Bus Rapid Transit system, located next to the A27 freeway and connecting the city centers of Breda and Utrecht in the Netherlands. It was concluded that the proposed Smart Bus system appears to be an economically and technically feasible form of mass transit.

BENEFITS

The deliverables of this project can be used for the proof of concept and promotion of the Smart Bus system to attract possible project partners and investors. The developed models can be used by STORM Eindhoven to further investigate vehicle concepts in terms of economic and technical feasibility. The proposed Smart Bus system can be up to 51% cheaper than a similar train system when autonomously operated at full occupancy over a 20 year system lifetime.

"Raymond has taken the challenge to study upscaling a Bus Rapid Transit system as an alternative for regional transit lines or even beyond, both on economical as well as on technical dimensions. I hope and seriously expect that due to his huge effort, Raymond's work might in due course appear to be a small but very important step towards a modern, flexible, affordable and efficient transit system that can sustain the important role of mass transport. Last but not least, I want to express my appreciation for Raymond's far-above-average level of thinking and acting, remarkably professional for his age. I would be surprised if this work would, in due course, not appear to be an intermediate step towards a very successful career in engineering."

Carlo van de Weijer, Head of TU/e Strategic Area Smart Mobility

RAYMOND WOUTERS, MSc PDEng

Preliminary Design of the Smart Bus Concept

DESIGN AND SIMULATION OF A CONCEPT FOR AN INTERCITY BUS RAPID TRANSIT SYSTEM

Mobility is a key factor within the current society and will expand over time due to economic growth, urbanization, and the increase of sustainable passenger cars. The expected mobility increase of 10-32% in the Netherlands in the period from 2014 to 2040 and scarceness of public space impose mobility problems for the near future. Therefore, a shift towards a sustainable form of road-based mass transit is required. This project aimed to establish the system and vehicle requirements of an intercity Bus Rapid Transit system that could fulfill these demands. Next, the project aimed to assess the feasibility concerns on system and vehicle level.

The most important design criteria for this new mass transit system are affordability, flexibility, reliability, compatibility, and capacity. Different stakeholder objectives were gathered and transformed into system and vehicle requirements. Based on these system requirements, the Smart Bus is defined as a high-speed, high-capacity, road-legal, battery-equipped, electric vehicle. The Smart Bus infrastructure will be a dedicated, shielded, two-lane asphalt busway, in this case, located next to the A27 freeway and connecting the city centers of Breda and Utrecht.

The proposed vehicle concept is a 25 m double-articulated bus that can carry 90 passengers. This vehicle meets the maneuverability and axle weight legislation and achieves equal high-speed stability performance at 130 km/h as truck combinations driving at 88 km/h. Even when using grey electricity, the proposed smart bus system emits 90% less CO_2 per pass-km than an average passenger car. Compared to a train, this system is 43% cheaper when manually operated or 51% when autonomously operated over a 20 year system lifetime.

CREDITS

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