PDENG PROJECTS 2020

Automotive/Mechatronic Systems Design

TU/e

EINDHOVEN UNIVERSITY OF TECHNOLOGY

The PDEng Automotive Systems Design, existing since 2011, 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.

Automotive/Mechatronic Systems Design - PDEng Projects 2020

PROF. DR. H. NIJMEIJER
DR. P.S.C. HEUBERGER
DR.IR. C.C.M. RINDT
IR. R. MEIJER

The 2018-2020 generation ASD/MSD trainees

With great pleasure we present you the results of the fourteen graduates of the PDEng program Automotive Systems Design of Eindhoven University of Technology with tracks ASD (7) and MSD (7) who started in 2018. The track of ASD started in 2011, and the track of MSD started in 2015. These tracks were motivated by the demand of the automotive and high tech industry, respectively. The program is also supported by the Eindhoven Artificial Intelligence Systems Institute. The program is driven by the rapid changes in the Dutch high-tech ecosystem with huge challenges in terms of multidisciplinary product and process design and engineering. This two-year post-master program educates its trainees in-depth in various automotive and mechatronic-related fields, as well as in personal and professional development.

This variation in disciplines is reflected in the 14 graduation projects that are presented in this booklet. The subjects of these projects are in the areas of cooperative and automated driving, prediction of energy consumption for electric busses, risk management for combustion engines, solar power storage installations, fiber array assembling, automation of fiber tape placing, sub-nanometer positioning of wavers, and treatment of retinopathy of prematurity.

Three graduation projects were in the field of cooperative and automated driving. For Valeo a generic longitudinal torque controller has been developed to address highway driving scenarios as well as parking scenarios. In the NWO (Nederlandse Organisatie voor Wetenschappelijk Onderzoek) project “I-Cave”, one trainee developed and implemented a framework to efficiently detect, track and identify potential target vehicles. The other trainee working in the I-Cave project developed a tracker that estimates the motions of the other road users by fusing the readings from all the sensors that detect the surroundings.

One graduation project in the field of electric driving was part of the EMEurope Research and Innovation project “Cloud Your Bus”. The trainee developed an energy consumption prediction toolbox based upon a novel energy consumption modelling technique and an adaptive energy estimation algorithm which has the capability to give better predictions on energy consumed by the electric city bus over a given route by using the real-world operation data. At DAF a trainee developed and validated two range prediction concepts: one based on field test data from Battery Electric Vehicles (BEV), the other using a white box model of the BEV combined with preview information.

Vehicles and their engines are becoming more complex due to the inclusion of more and more components and sensor and control blocks with the overall control software, which can increase the risk of product failure. At DAF another trainee worked on this problem by developing an architectural framework for managing the risk of product failure, which was based on a systems engineering approach.

Propelled by electric mobility and photovoltaic systems, the demand for energy storage systems is increasing. In a project funded by RVO (Rijksdienst voor Ondernemend Nederland) and in cooperation with Kago Electronics a trainee created a simulation platform for investigation of properties of a switching battery management system. In addition, his simulations proved that the concept of Maximal Power Point Tracking by choosing a proper subset of cells from the pack is indeed working.

The high cost of packaging is the greatest challenge to commercializing photonics products according to Phix. A trainee worked for them on process improvements for an automated fiber array assembling machine. The Materials Innovation Institute (M2I) co-funded this project.

Three other graduation projects co-funded by M2I were on fiber tape placing for Tikael Composite Machinery. The first trainee designed a dedicated prototype industrial winding head where the tape winding technology can be tested up to 1 m/s, which is four times higher than existing systems. The second trainee designed a prototype placement head which can use dual layer tapes with speeds up to 1 m/s. And the third trainee designed a test system where the dual layer tape technology can be tested at speeds up to 1 m/s.

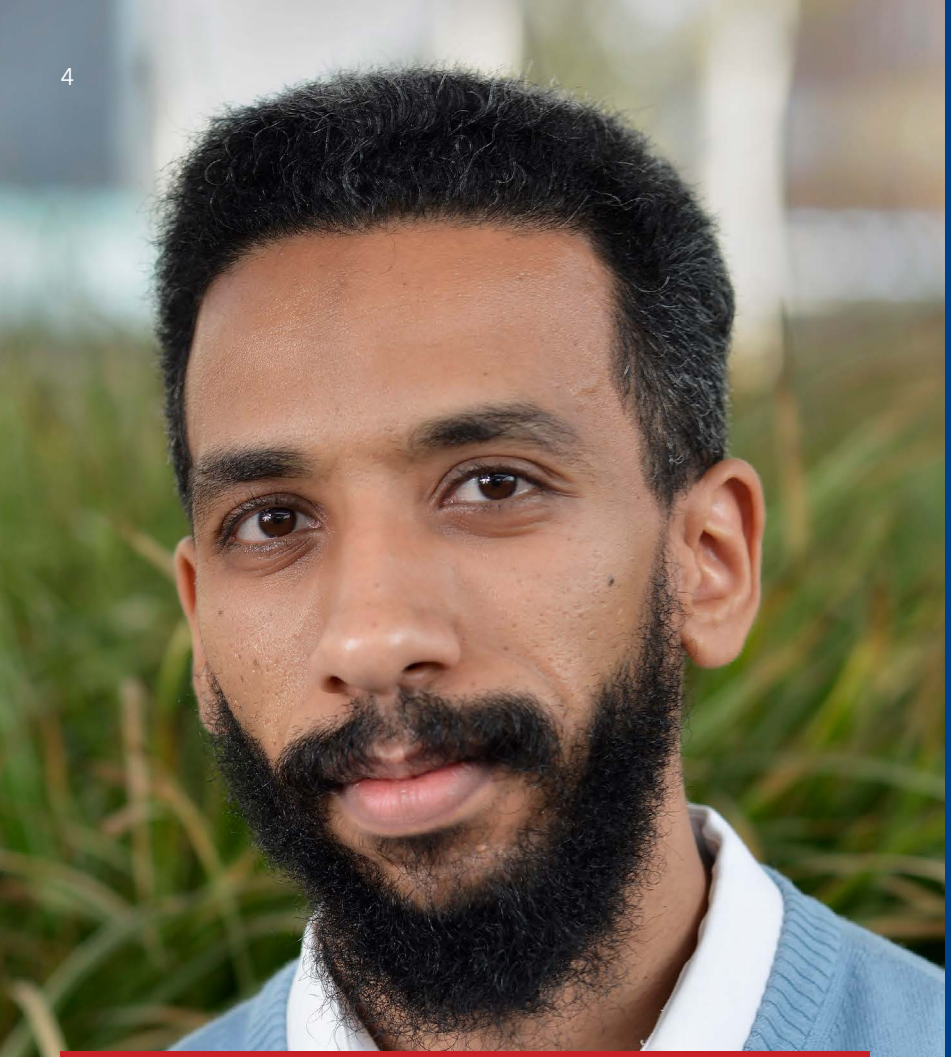
The semiconductor industry has been growing in the past few decades. ASML is a leading supplier of wafer scanners to the semiconductor industry. In order to achieve the required accuracy, the wafer stage is actuated through long and short stroke actuators. In a project funded by Eindhoven Engine Regiodeal a trainee designed an actuator concept design for the long range positioning linking the control relevant actuator stiffness to mechanic and electrical optimal geometries.

Retinopathy of prematurity (ROP) is caused by abnormal growth of retinal blood vessels leading to an irreversible visual deficiency in premature babies. The existing solutions to screen and treat ROP are not able to address the high demand in developing countries. At Eindhoven Medical Robotics one trainee designed and implemented the first prototype of a hand-held surgical system including optics and automated laser delivery control system. Another trainee designed a prototype of a contactless ROP treatment system to simulate the system functionalities mainly concerned with the motion of the treatment unit and its alignment with the patient's pupil.

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

Henk Nijmeijer (left per April 2021) and
Camilo Rindt (started in April 2021)
Scientific Directors

Peter Heuberger (left per November 2020) and
Riske Meijer (started in June 2020)
Program Managers



"As Tier 1 ADAS supplier, Valeo aims to provide a product that can be utilized by multiple OEMs. Driven by the current electrification trend, Momen's project focused on the design of a longitudinal torque controller, which converts the kinematic commands from the Valeo ADAS products robustly in multiple target vehicles.
Momen took the responsibility for the full design chain, from requirements specification and architectural design, up to the algorithm development and verification. We want to thank Momen for his valuable contribution, from which our products will surely benefit."

Ir. Gerald Koudijs
System Engineer, Valeo Schalter und Sensoren GmbH

CHALLENGES

The main challenge of the project was to make the developed longitudinal torque controller a generic one that works for different vehicle classes. This necessitated the controller to be very robust, especially against parameter uncertainty, yet with good performance. Another challenge was to ensure its seamless integration within the existing architecture of Valeo's ADAS platforms which restricted the used interfaces to only the existing ones.

RESULTS

A generic longitudinal torque controller has been developed to address highway driving scenarios and parking scenarios. The controller has been integrated within the existing architecture of Valeo's ADAS platforms with validation been carried out in a simulation environment.

BENEFITS

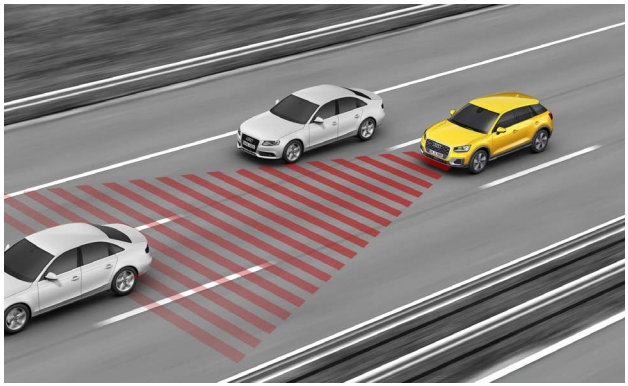
The developed longitudinal torque controller will enable Valeo to have the necessary flexibility to accommodate their clients' needs. It also opens the door for torque vectoring applications in electric vehicles enabling Valeo to further expand their range of products.

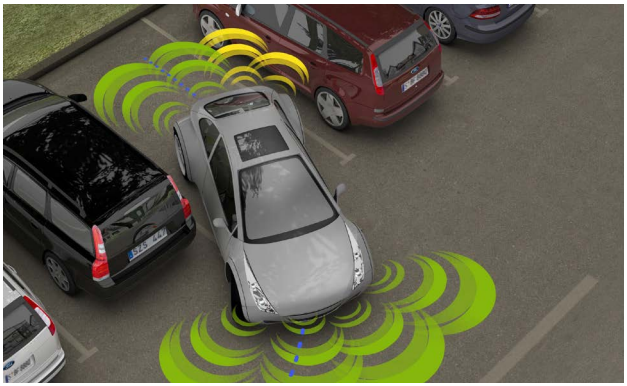
MOMEN ABDALLATIF, MSc PDEng

Development of a Longitudinal Torque Controller with Multiple Motion Requesters for Automated Driving

Driven by safety and fuel efficiency concerns, nowadays, a great focus in the automotive industry is given to the development of ADAS systems. Valeo is one of the global market leaders in this domain, maintaining a vision of constantly improving their existing functionalities by utilization of the latest technological advancements. One of their efforts in this area is to offer their clients the flexibility of choosing between an acceleration interface or a torque interface for the longitudinal control of their vehicles.

Currently, Valeo provides an acceleration interface for kinematic commands of the vehicle longitudinal control between their high-level controllers and the low-level controllers from the OEM's side. The goal of this project was to develop a generic longitudinal torque controller to be integrated into Valeo's ADAS platforms to provide the additional option of a torque interface for kinematic commands of the vehicle longitudinal control.





CHALLENGES

The main challenge was to design and realize a system in which trade-offs and inter-connected requirements were present for its sub-systems. These challenges become more significant when it comes to precision manufacturing and integration of an invasive surgical system.

RESULTS

Design and development of a surgical system have been performed and a complete V-Model has been implemented. Furthermore, a novel conceptual design was proposed which includes the required optics and laser projection control system. The complete system design was done, starting from high-level market analysis and studying clinical requirements in India. A consistent set of system specifications was elucidated to fulfill the customer and application drivers from various viewpoints.

BENEFITS

The designed and realized system enables Eindhoven Medical Robotics to move forward this project by reiterating the V-Model and further improving the sub-systems. This helps the company to get closer to its ultimate goal of performing clinical trials and preparing the product to be launched in the future. Potential applications of this system to address conditions other than ROP can also be explored in the future.

"Arash has done a superb job in all phases of the so-called V-model. From the start of his PDEng project Arash set himself extremely challenging goals as he insisted on the finalization of a useable prototype device within his training period. This meant, amongst others, that he had to learn and master himself in optical design, a completely new discipline for which he had never received any training. He was not only very fast in making a conceptual optical and mechanical design and a final design, but also was very fast and pro-active in having these designs procured and manufactured."

Ir. Siddarth Khalate, PDEng
System Architect, Eindhoven Medical Robotics
Anupam Nayak, BSc MBA
Founder & CEO - Eindhoven Medical Robotics
Ir. Anton van Dijsseldonk
Program support TU/e High Tech Systems Center

ARASH ARJMANDI, MSc PDEng

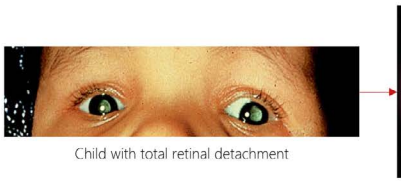
Design and Development of an Experimental Hand-Held System for ROP Laser Treatment

ROP is a disease associated with the vision loss of premature babies and a major cause of childhood blindness around the world. This disease is uniquely characterized by the retinal detachment due to abnormal growth of retinal blood vessels and leads to an irreversible visual deficiency in premature babies. Approximately 15 million babies per year are born premature, out of which thousands develop severe ROP and become blind.

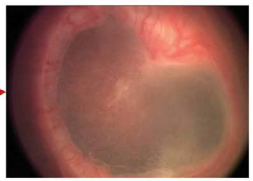
The existing solutions to screen and treat ROP are not able to address the high demand in developing countries. These solutions have considerable drawbacks that lead to less accurate and efficient diagnosis/treatment procedures and result in high fatigue on the ophthalmologists as well as exposing the patients to the numerous risks.

To this end, Eindhoven Medical Robotics (EMR) has initialized in 2017 a project in for developing a new laser delivery surgical system to diagnose and cure ROP. This new system is primarily intended to be more efficient, accurate and autonomous.

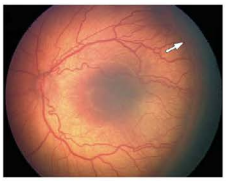
The ultimate goal of this project was to design and implement the first prototype of this surgical system including all the essential functions. This goal was realized by designing and implementing a system including optics and automated laser delivery control system. In order to verify different design and implementation aspects, multiple integration and system tests have been performed and presented.



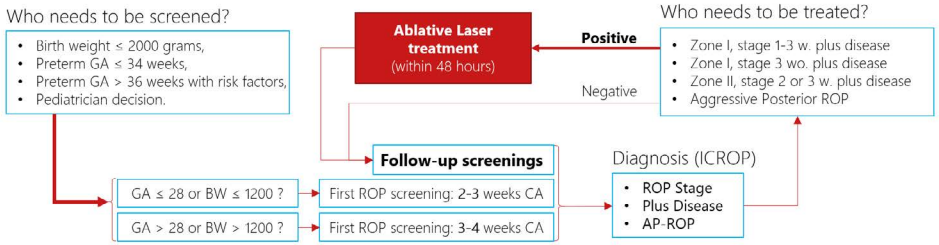
Child with total retinal detachment

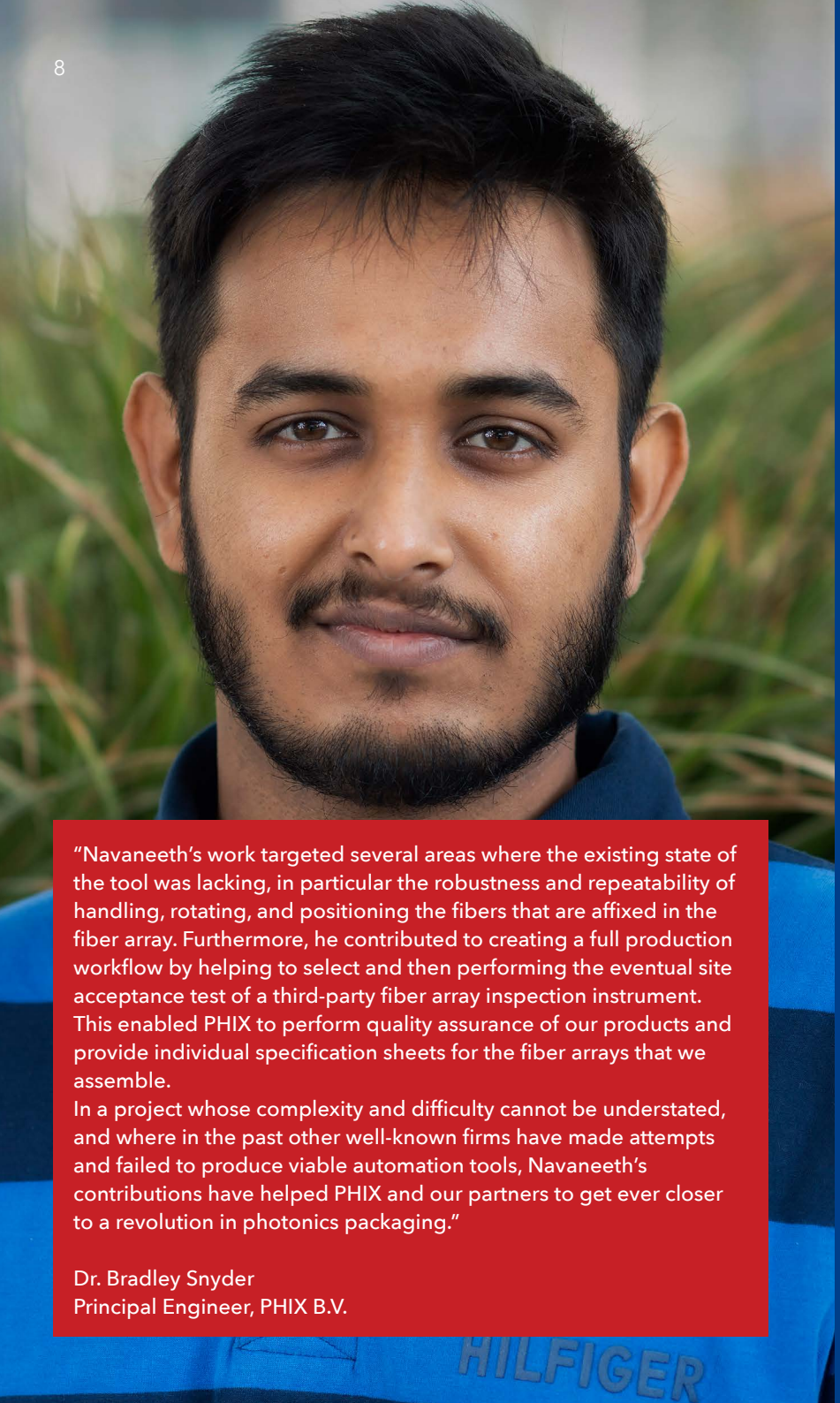


Stage 5 ROP



Moderate Stage 3 ROP





"Navaneeth's work targeted several areas where the existing state of the tool was lacking, in particular the robustness and repeatability of handling, rotating, and positioning the fibers that are affixed in the fiber array. Furthermore, he contributed to creating a full production workflow by helping to select and then performing the eventual site acceptance test of a third-party fiber array inspection instrument. This enabled PHIX to perform quality assurance of our products and provide individual specification sheets for the fiber arrays that we assemble.
In a project whose complexity and difficulty cannot be understated, and where in the past other well-known firms have made attempts and failed to produce viable automation tools, Navaneeth's contributions have helped PHIX and our partners to get ever closer to a revolution in photonics packaging."

Dr. Bradley Snyder
Principal Engineer, PHIX B.V.

CHALLENGES

The project involved working with other project partners. One of the major challenges was to ensure the designs and concepts could be integrated into the existing system. The optic fiber cables used in the assembly of fiber arrays tend to coil. This makes the handling, rotation, and positioning of these fibers at micrometric accuracies challenging.

RESULTS

Concepts were suggested for improving handling, rotating, and positioning fiber arrays. The design concepts were theoretically assessed for feasibility and the most suitable concepts were chosen based on their ability to satisfy the requirements. An adhesive study was carried out to suggest alternatives that could improve the performance and reduce the high wastage to bring down production costs. Finally, a fiber array inspection tool was acquired and the site acceptance test was performed to complete the production workflow.

BENEFITS

The suggested concepts for handling fibers are developed considering the coiling nature of the fiber. These concepts can eliminate the material preparation required to straighten the fiber and reduce cycle times. The suggested adhesives can reduce the large wastage of adhesives and provide better fiber substrate bonding. The acquired fiber array inspection system can be used to gain insights into the quality of the final product and improve the existing production process.

NAVANEETH BHAT, MSc PDEng

Process Improvements in an Automated Fiber Array Assembly Machine

A photonic integrated circuit is a device that integrates multiple photonic functions such as a light source, waveguides, and photonic chips as such in a similar fashion as electronic integrated circuits. A fiber array unit is an assembly of multiple optic fibers that transmit light pulses to carry information to and from the photonic integrated circuits. The fiber array units form the building block of the photonic modules. The assembly of fiber array units involves placing multiple optic fibers in a high-precision V-groove chip with another flat lid on top and optically polishing the end face. The existing manual process leads to a repetitive process and low productivity. This results in higher costs and longer waiting times for these fiber arrays.

PHIX B.V. is a company that provides packaging and assembly services for photonic integrated circuits. PHIX, in association with a few other companies, is working on the development of an automated solution to assemble fiber arrays called the Fibber Array Assembly Technology (FAAST). The FAAST machine uses high precision gantry system to assemble fiber arrays. Optic fibers are individually tacked on to the back of the V-groove glass block, and a flat glass lid is placed on top at the end. PHIX BV plans to mass-produce fiber arrays on demand to reduce lead times and drive down costs.

The main objective of the project was to create a stable and repeatable process. As a part of the project, three tasks were carried out: process and design improvements were suggested to improve the handling of the fibers, an adhesive study was conducted and alternatives were suggested to reduce the wastage and improve performance and a fiber array inspection system was acquired and validated to create a complete production workflow.

CHALLENGES

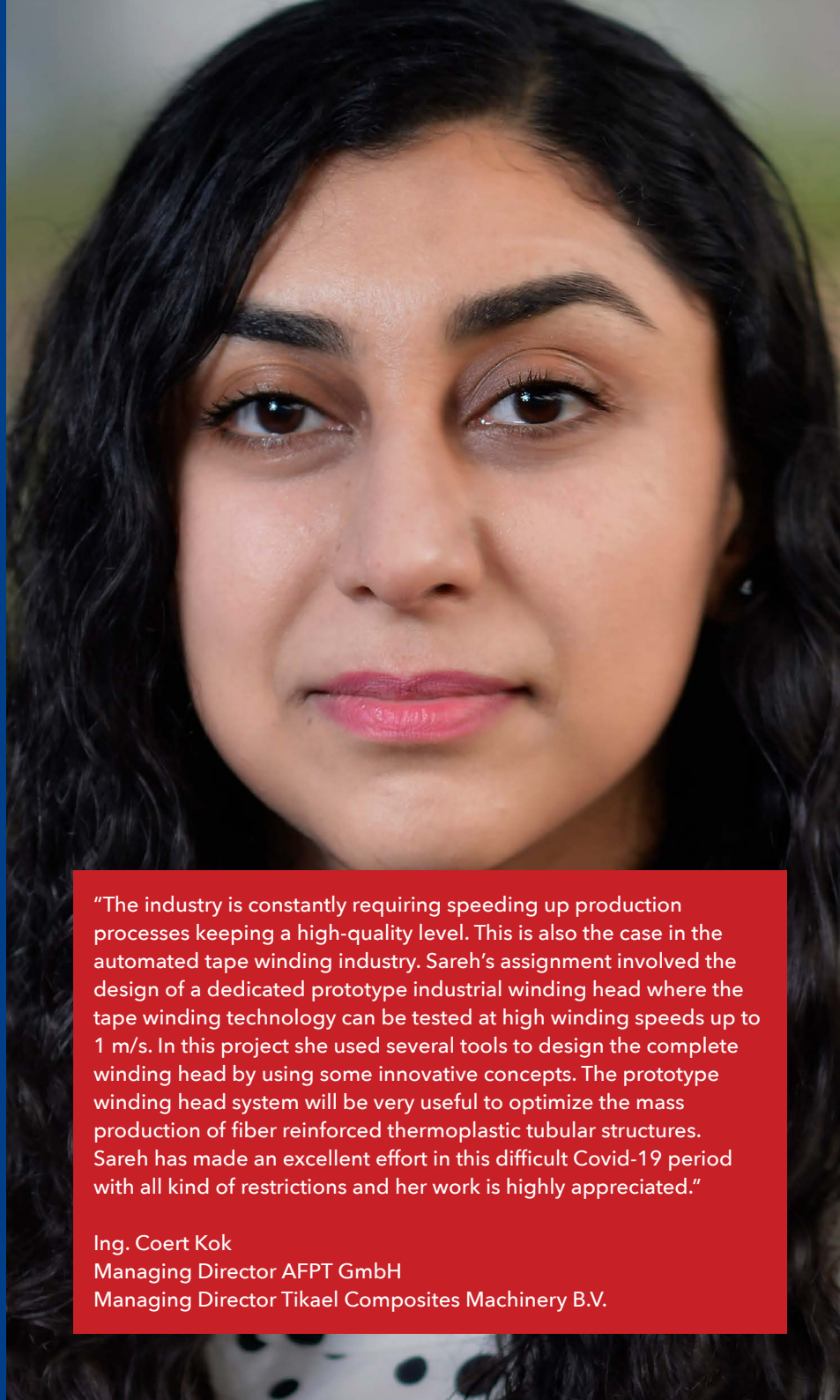
There were two main challenges in this project. First, the immaturity of the tape winding technology, which made it challenging to find well-defined models or proven information about the system behavior. Therefore, extensive research and multidisciplinary knowledge was required for creating working concepts. Second, the project timeline was very tight, considering the requirement of building such a complex system, starting from scratch to the final prototyping steps.

RESULTS

The designed prototype is a proposed system for dedicatedly production of thermoplastic cylindrical-shaped structures. This prototype has achieved a system level optimization compared to the existing systems which brings the technology closer to the industrial mass production applications. Besides, the architecture of the system has been developed with flexibility in mind, which will facilitate future enhancements.

BENEFITS

The prototype tape winding head system developed in this project, will be useful to optimize the mass production of thermoplastic tubular structures as it has reduced number components and interfaces with respect to the alternative existing systems. This new system can be the foundation of a new generation of tape winding systems for achieving high volume production of thermoplastic tubes.



"The industry is constantly requiring speeding up production processes keeping a high-quality level. This is also the case in the automated tape winding industry. Sareh's assignment involved the design of a dedicated prototype industrial winding head where the tape winding technology can be tested at high winding speeds up to 1 m/s. In this project she used several tools to design the complete winding head by using some innovative concepts. The prototype winding head system will be very useful to optimize the mass production of fiber reinforced thermoplastic tubular structures. Sareh has made an excellent effort in this difficult Covid-19 period with all kind of restrictions and her work is highly appreciated."

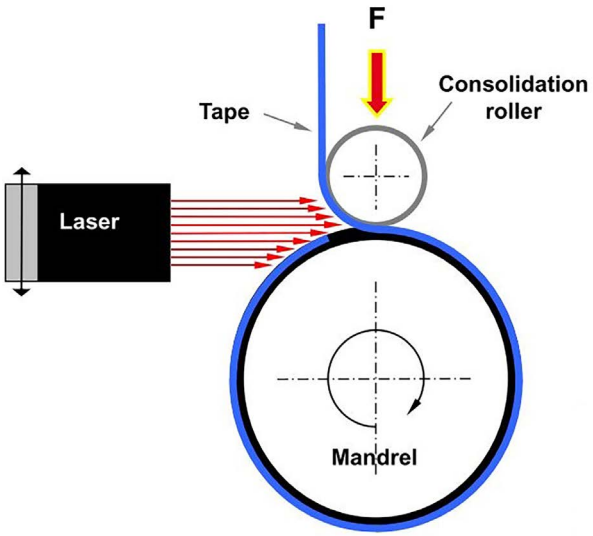
Ing. Coert Kok
Managing Director AFPT GmbH
Managing Director Tikael Composites Machinery B.V.

SAREH HEYDARI, MSc PDEng

Laser-Assisted Tape Winding System Design and Development

DESIGN AND DEVELOPMENT OF A LASER-ASSISTED CONTINUOUS TAPE WINDING HEAD FOR THERMOPLASTIC TUBES PRODUCTION MACHINERY

From the early stages of the development of the composite materials, they became attractive for several industries, due to their advantages over the traditional materials, specifically their high structural strength to weight ratio. However, there is an increasing demand for improving the speed of the production of these components to make this substitution economical. A common group of thermoplastic components is thermoplastic tubes, which are produced by tape winding technology. As it is a recent technology, there are only a few research and development available about it and it has a high potential for investigations especially with the goal of moving towards industrial mass production of the thermoplastic tubes. To this end, Tikael Composite Machinery has started investigating in innovative tape winding systems design to optimize the process, which can lead into high volume production of thermoplastic tubes.



During this project, a tape winding head based on the minimum viable product concept was developed, to ensure that the new system will not carry any redundancies of the current tape winding systems. The tape winding head was developed based on a system engineering approach which allows analyzing customer needs, capturing important project requirements early on and building a system architecture as the base for the design in this work and future enhancements. Finally, by generating several innovative mechanical concepts to fulfill the functions required in the tape winding process a new tape winding head was designed.

"The unique online energy consumption prediction model developed in the context of the Cloud-Your-Bus (CYB) innovation programme has demonstrated to potentially bring the energy prediction error margin down. When made available to bus operators, the more accurate information can facilitate better and faster decision making and help optimise route and charge planning throughout the day. This in turn has a massive positive impact on both capital and operational expenses and will help accelerate the transition to zero-emission public transport in Europe and beyond. The energy prediction tool that has been developed as part of this project is a living example of how academia and business can work together to develop new tools and to create a positive impact on one of the biggest challenges we collectively face: creating a more sustainable world.
At Sycada, we are proud of the work that has been achieved and I want to take this opportunity to express our sincere thanks to Dhruv Jagga and his colleagues and mentors at TU/e for having brought this work from research to practical implementation."

Kristian Winge, MSc MBA
CEO, Sycada B.V.

CHALLENGES

The transition to electric counterparts in the public transport system turns up to bring the unforeseen challenges with the higher factor of operational uncertainties. The electric buses drive significantly less distance as compared to their fuel-based counterparts on a fully charged battery. It requires special occasions for charging during the operation. Furthermore, the energy usage pattern of electric buses is more uncertain than the diesel buses. This induces more dynamicity in operation and tactical planning and hence introduce more vulnerability.

RESULTS

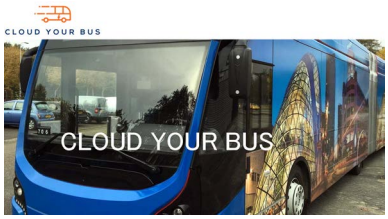
A cutting-edge energy modelling technique is used amalgamated with the advanced energy estimation algorithm to create a toolbox to give more accurate predictions on the energy estimates. This toolbox has capabilities to self-learn from the data perceived from the environment. It handles any perturbations in the operational domain of the large fleet of vehicles while ensuring the robustness in the efficiency and accuracy of energy predictions.

BENEFITS

The system developed during the project will undoubtedly enable the bus operators with real-time insights on the status of the electric buses and their batteries. With this real-time information in hand, the dynamic re-planning of the operations of these buses can be facilitated. This provides a sustainable solution that can lead to avoiding operational uncertainties and vulnerabilities and helps reduce the costs of operation.

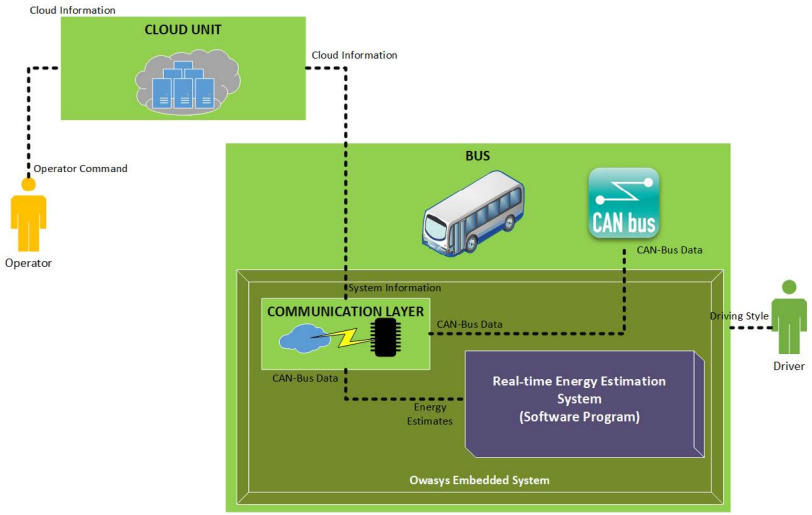
DHRUV JAGGA, MSc PDEng

Cloud Your Bus: Real-time Energy Consumption Prediction for Electric City Buses



Zero-emission transportation is blooming swiftly with the earliest movers to be public transport in this field. Electric buses are replacing conventional ICE engine buses in the city areas in entire Europe to deal with the issues concerning greenhouse-gas emissions. The bus operators are amongst the top pioneers to adapt to the leading-edge technologies to make this transition possible.

The transformation of public transportation from classical ICE buses to electric buses brings about startling challenges in operational ambiguities, vulnerabilities, and costs. The ambition of the EU funded "Cloud Your Bus" project is to stimulate the transition to zero-emission public transport in Europe. The business goal revolves around reducing the risks and costs of this transition to zero-emission bus operations. The project concentrates on the establishment of an online synergic electric bus (e-Bus) data platform with the intent to establish operational excellence in zero-emission public transportation. This data platform is intended to be kept independent from the original equipment manufacturer (OEM) and will reinforce the operational usage of a fleet of electric city busses.



The scope of the project evolves around developing an energy consumption prediction toolbox based upon a novel energy consumption modelling technique and an adaptive energy estimation algorithm which has the capability to give better predictions on energy consumed by the electric city bus over a given route by using the real-world operation data. This, in return, facilitates the bus operators in making optimum schedules for the buses.

CHALLENGES

The main challenge here is to develop a system that identifies a specific type of car to follow. Training a specific detector that can identify this vehicle robustly in real-time is challenging and requires a lot of training data. A proper abstraction of the methodology was necessary to develop an efficient detector using open source solutions. Secondly, since monocular cameras which are used for surround vision lack depth information it is difficult to obtain a universal solution that can estimate the pose of detected objects in varying scenarios.

RESULTS

A framework was developed to efficiently detect, track and identify potential target vehicles and was implemented on an embedded platform, the Nvidia Drive PX 2. The system estimates the relative position of the leading Twizy, and also provides the relative heading angle. Furthermore, multiple modules such as free space detection and lane detection are also integrated and tested on a prototype vehicle.

BENEFITS

The implemented system acts as a platform for testing high level path-planning and platooning control algorithms. The camera detections are suitable for fusion with other sensors, like radar measurements, thus improving the reliability and overall perception performance. In addition, specific car identification aids in the implementation of cooperative vehicle control.

"Ashton has been working in the i-CAVE project, which is a large NWO project, focused on automated and cooperative vehicles. He has created a framework for a set of cameras which was implemented on the research vehicle. He managed to create a detector that estimates the relative position of the Twizy and that also gives the heading angle with respect to that. Additionally, multiple modules, such as lane detection and free-space detection have also been implemented.
With the work of Ashton, another step has been set to achieve fully automated and cooperative driving vehicles. Together with the work of fellow PDEng researcher Varun Khattar, the environmental perception of the Renault Twizy has taken another step in the right direction."

Dr.ir. Tom van der Sande
Teacher/Researcher I Project Manager i-CAVE, TU/e

ASHTON MENEZES, MSc PDEng

Design & Implementation of a Surround Vision System for Cooperative and Autonomous Driving

OBJECT - LANE - FREE SPACE DETECTION AND POSE ESTIMATION OF TARGETS

In recent years, a major focus in the automotive field has been on improving road throughput and safety. The i-Cave research program addresses these challenges by developing dual-mode vehicles that can drive as a platoon of vehicles where the collective behaviour is improved, and operate autonomously in high traffic scenarios. Enabling these modes requires an advanced perception system that provides accurate and robust measurements of surrounding objects for good high-level spatial reasoning. Hence a project was initiated aiming towards the development of a surround vision system.

The most important objective in cooperative driving is following the car in front of you, which in this case is a Renault Twizy. The goal here, was to develop a vision-based system that is able to identify this particular car. In addition to that, having knowledge of the location and orientation of the leading vehicle was of the utmost importance to achieve successful cooperative automated driving. To that effect, using a system engineering approach, a framework with a set of cameras was developed to detect and estimate the location and heading angle of the leading vehicle. Furthermore, the system also detects the lanes and the drivable free space around the vehicle which is crucial for obstacle avoidance and path planning.

"Engineering is often referred to as the art of making difficult things simple. In his work Kamel Mohamed has demonstrated that he is capable of making a design that excels in its simplicity, while the problem that had to be solved was actually quite challenging."

Anton van Dijsseldonk
Program Support, TU/e High Tech Systems Center

CHALLENGES

The system to be designed has to fit in the environment of low-and middle-income countries. The environment enforces that, the system must be cheap, mobile, and easy to use. Furthermore, the system must not induce and untried medical practices to ease the process of obtaining legal usage permissions.

RESULTS

In this project, A prototype of the contactless ROP treatment system was designed and manufactured to simulate the system functionalities mainly concerned with the motion of the treatment unit and its alignment with the patient's pupil. CAFCR framework was used to capture requirements from stakeholders to create the concept and the prototype. Manufacturing of the prototype was done in collaboration with the equipment and prototype center at TU/e.

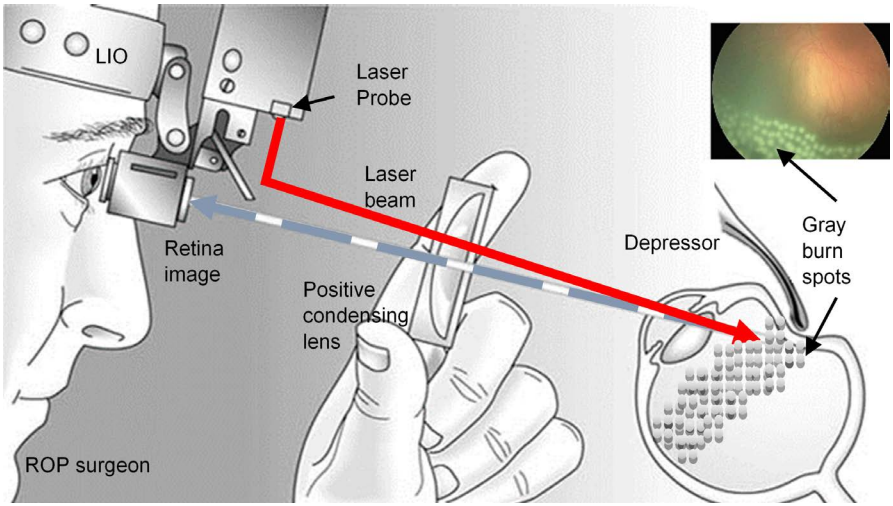
BENEFITS

In comparison to the conventional operation, the developed prototype eliminates the wearing of the headgear to see and shoot the retina, alignment, and motion of the lens with respect to the pupil. The surgeon will still need to use the depressor to keep the eyeball fixed and press the foot paddle to enable the laser. The next development step is to complete the optics unit and integrate it with the developed prototype.

MOHAMED KAMEL, MSc PDEng

Prototype Development of a Contactless Solution to Treat Retinopathy of Prematurity

Retinopathy of prematurity (ROP) is a potentially blinding disease caused by abnormal growth of retinal blood vessels in the eyes of premature infants. It is quite uncommon for premature infants born to high-income countries to develop sight loss threatening ROP. This is not the case for low- and middle-income countries, where; ROP is contributing to almost 40% of childhood blindness.



The most common and effective treatment method is laser photocoagulation. The laser beams are used to burn the abnormal vessels on the retina's surface. During the operation, the ROP surgeon is using a depressor to hold and rotate the eyeball. The other hand is occupied with holding a positive condensing lens. The surgeon is wearing a laser indirect ophthalmoscope (LIO) on the head. The LIO provides illumination needed to see the retina and it carries the laser probe. The laser is controlled (ON/OFF) by the foot paddle. The laser's mode, power, and exposure time settings are controlled using the console. The laser beams travel from the probe in the LIO towards the condensing lens then towards the retina of the premature infant. The falling beams would destroy the abnormal blood vessels creating gray spots on the surface of the retina.

The operation is extremely challenging in the environment of low-and middle-income countries. Therefore, Eindhoven Medical Robotics (EMR) and Eindhoven University of Technology (TU/e) have set their goal to create a cheap and smart solution to help the ROP surgeon which is the goal of this project.

CHALLENGES

The current approach of risk management does not provide a clear overview of the diagnostics of different failure modes as there is no guideline or unified approach that must be followed by the different system owners. This resulted in a very restrictive architecture. Thus, the newly developing risk management tooling should allow a better understanding of all the interactions between the different systems, sub-systems, and components with reduced complexity.

RESULTS

An architectural framework has been developed based on the systems engineering approach that gives better insight into the engine, its subsystems, and components. The architecture covers the detailed structure, functions, and malfunctions of the engine oil system and its interactions with other systems. This approach enabled the implementation of a well-defined FMEA based on the new AIAG VDA FMEA approach, along with a shift to a dedicated risk management software.

BENEFITS

The solution implemented in this project is consistent and repeatable throughout the complete vehicle. This will structure the architecture of the product by means of creating clarity in the system boundary and interfaces which will further ease the process of maintaining a well-defined inventory of failures/risks. Once this approach is implemented throughout the vehicle, the organization will mostly never miss any risks and this can completely avoid warranty issues.

"Driven by legislation, Total Cost of Ownership and customer satisfaction, diesel powertrains are continuously optimized and are increasing in complexity at the same time. These complex systems require more comprehensive methods for Risk Assessment based on Failure Mode & Effects Analysis (FMEA). To investigate options for the transformation from an isolated spreadsheet based risk assessment approach to an integrated approach with a well-defined architecture, this PDEng project has been defined.
Akshay worked on this project with full enthusiasm where he used fresh ideas and an open view on the organization to set up the base architecture and evaluated the proposed tooling. He established a solid base for further improvements on the risk assessment processes within PACCAR. Overall I enjoyed Akshay's pleasant and enthusiastic personality within the team."

Ir. Jarno Strik
Engineering Supervisor System Definition, DAF Trucks N.V.

AKSHAY PAKKATH, MSc PDEng

Architecture Setup for Risk Management Tooling

CAPTURING THE STRUCTURAL, FUNCTIONAL, AND MALFUNCTION ARCHITECTURE OF THE DAF MX-ENGINE

Internal combustion engines are still the main propulsion system in road transport. It is really hard to replace them as the power plant in most vehicles, especially in heavy-duty trucks. Owing to digitalization these vehicles and their engines are becoming ever more complex and interactive. Hence most of the systems require changes to their architecture to transform from a mostly mechanical system to a mechatronic system. This is mainly intended to keep improving the product quality to meet legal compliance. Thus, the motivation for this project comes from the existing demand within DAF Trucks for quality improvement. This will also help in minimizing the warranty costs because most of the time the engineering or design problems are discovered only after the product has been released into the market. Therefore, the limitations have been identified in the current approach of risk management followed within the organization, which is insufficient to manage complexity.

One of the secondary drivers for the project is the increasing need within the organization for further improving the diagnosability of the Engine. To assess the necessity or redundancy of diagnostics, having a well-organized inventory of failure modes is a prerequisite. This also allows in troubleshooting a malfunctioning product.

This project focused on managing the risk by developing an architectural framework based on systems engineering approach. The approach has developed a well-defined structural, functional, and malfunction architecture in a dedicated risk management tooling. This enabled an effort-less implementation of comprehensive FMEA based on the new AIAG VDA FMEA framework.

"Siddhesh's assignment involved the design of a test system where the dual layer tape technology can be tested at high speeds up to 1 m/s, which is four times faster than the existing systems. In this project, he used several tools to design the complete mechanical setup and selected the sensors necessary to work at the required design speeds. The system will be very useful to optimize the developed tapes and to evaluate the boundaries of the high-speed laser assisted tape placement technology. Siddhesh has made an excellent effort in this difficult Covid-19 period with all kinds of restrictions and his work is highly appreciated."

Ing. Coert Kok
Managing Director AFPT GmbH I Managing Director Tikael Composites Machinery B.V.

CHALLENGES

There were two major challenges in the project. First, to select a robust sensor for pre-heating system which can reliably detect tape moving at high speed. The second challenge in the project was designing an experimental setup for high-speed tape transport. Accurate modeling of the plant was crucial for understanding the effect of various parameters on tape tension and speed control.

RESULTS

The designed test setup can transport the tape at the speed of 1 m/s while maintaining positive tension. The test setup also includes the modified pre-heating system consisting of a contrast sensor laser and thermal camera. The simulations carried out showed the design of the test setup and pre-heating system meet the performance requirements.

BENEFITS

The newly designed pre-heating system is instrumental in achieving three-fold productivity increase and accuracy improvement. Also, the simulation models developed for the experimental setup can be adapted for gaining insights into the mechanics of tape transport, which is crucial in the AFP process.

SIDDHESH VIDYADHAR RANE, MSc PDEng

Design and Verification of Pre-heating System for Automated Fibre Placement (AFP) Process

Tikael Composite Machinery BV is a leading supplier of laser-assisted AFP systems. These machines are used by their customers for the production of fibre reinforced thermoplastic components. In the AFP process, a tape of composite material is used as a raw material to produce composite components or locally reinforce existing structures. Productivity and accuracy are the major challenges in making the reinforcement process viable for mass production.

It was observed that cutting continuous tape inside the tool is the bottleneck in improving productivity and accuracy. Tikael has developed a new type of pre-cut composite tape, also known as Dual Layer Tape (DLT). The DLT consists of pieces of composite tape pasted on paper carrier tape, which can improve the productivity and accuracy of the existing systems. The new tape requires modifications in the current pre-heating system to avoid burning or heating of the carrier tape. Also, the newly developed pre-heating system needs to be experimentally verified by developing a test setup.

CHALLENGES

Correlating electrical loads with temperature for prediction of auxiliary load was a significant challenge. So, a complete split-up of all loads and their dependence on temperature was made and summed up to produce the auxiliary load. More work needs to be done to improve the accuracy. Another challenge was to choose the parameters for the baseline strategy and improve the correlation factor between the selected independent factors and the fuel economy.

RESULTS

I devised two strategies to estimate the fuel economy of the electric truck, with which the range can be determined. Based on the information available at the time, the algorithm uses one of the two strategies to provide the most accurate range prediction. An on-demand stamina mode strategy was also formulated to reduce the energy consumption by limiting the maximum speed, resulting in increased range.

BENEFITS

DAF can now judge better if their truck will reach a destination from a given location, or predict how far the truck can travel from the current location with the given battery level. This can help improve the reliability of service and schedule the charging sessions more efficiently. The stamina mode could provide the truck incremental range, thereby helping avoid the rare, but not uncommon, empty battery mid-trip.

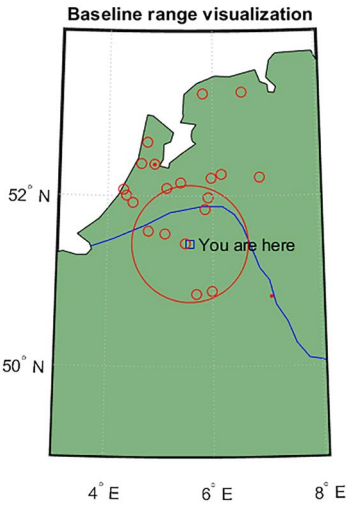
"Achyuthan developed and validated two range prediction concepts: one based on field test data from Battery Electric Vehicles, the other using a white box model of the BEV combined with preview information. Because of the corona crisis, implementation on a real vehicle became impossible, and gathering necessary information from the stakeholders got very difficult. Anyway, the work gives a clear overview of the developed range prediction concepts, plus recommendations on further steps."

Dr. Ir. Rudolf Huisman
Senior Control Engineer, DAF Trucks N.V.
Part-time Assistant Professor, TU/e

ACHYUTHAN SUNDARRAJAN, MSc PDEng

Range Prediction Algorithms and a Stamina Mode Strategy for Battery Electric Trucks

With their increasing market share, electric trucks necessitate the knowledge of range because the charging stations are sparser than petrol stations, and because timely delivery of goods is essential to maintain supply chains. Therefore, this project predicts the range of a DAF electric truck, using a variety of data, and explores a 'stamina mode' strategy to extend the range.



An algorithm determines the range based on the vehicle status and external conditions, using a physics-based model or a data-driven model, depending on criteria. In the physics-based model, the vehicle parameters and route data are used. It is verified for accuracy, by simulating actual routes in Eindhoven and Amsterdam. A sensitivity analysis is also performed on the results. The stamina mode works by reducing the energy consumption, by reducing the maximum speed of the truck in steps of 10 km/h until the desired range is achieved. This reduction, which provides a pragmatic tradeoff between speed and range, is recommended to the driver. The project follows a systems engineering approach, adopting the V-model for development, and CAFCR technique for architecture.

"Edoardo's assignment involved the design of a prototype placement head which can use dual layer tapes with speeds up to 1 m/s, which is four times faster than the existing systems. In this project he used several tools to design the complete prototype head and selected all necessary the components. The prototype placement head will be very useful to optimize the placement process strategies and optimize the practical use of the dual layer tapes.
Edoardo has made an excellent effort in this difficult Covid-19 period with all kind of restrictions and his work is highly appreciated."

Ing. Coert Kok
Managing Director AFPT GmbH
Managing Director Tikael Composites Machinery B.V.

CHALLENGES

The main challenges of the project were to select the components for a new robotic system and to design a new end-effector able to produce composite flat structures; furthermore, the new robotic system can partially reinforce an already existing structure and it might become a consistent help in the realisation of 3d composite structures in the future. The main requirements for the new system were the increase of the production speed and an improvement of the quality of the finished components.

RESULTS

The industrial machinery developed during the project is made up of the robot head (end-effector) mounted on the robotic system consisting of a Gantry robot and a Stewart platform. The end effector uses two laser heating sources to optimize the bonding process of the composite plies and it thus improves the quality of the components produced. In addition, the use of pre-cut composite strips facilitates a faster pace process.

BENEFITS

The use of composite materials reduces considerably the weight of the structures, it offers the possibility of creating components of various shapes and sizes and guarantees excellent mechanical resistance and anticorrosive properties. The demand of composites materials is rapidly increasing in many fields such as the aerospace, piping and automotive sectors. The precision and repeatability provided by the new robotic system and end-effector allow the efficient realization of high-quality composite structures, while reducing the production time for each component produced.

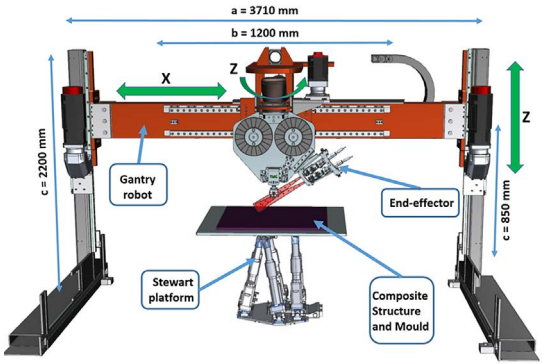
EDOARDO FRANCESCO TROPEANO, MSc PDEng

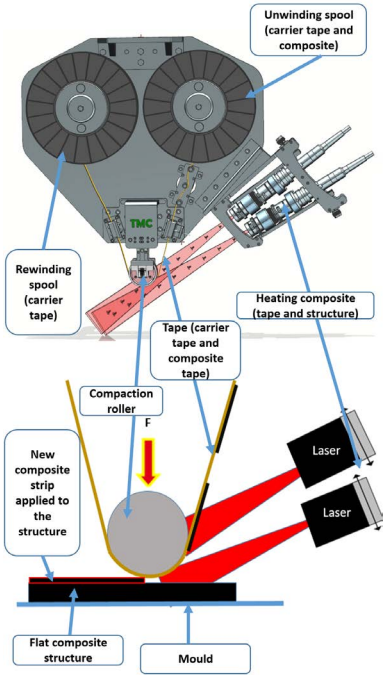
Design of an Automated Fiber Placement Plant for Flat Components with a Cooperative Robotic System

A composite material can be defined as the result of the combination of two or more different materials which combined together improve the performance level of the end-material itself.

In the Automated Fiber Placement (AFP) process, an automated robotic system employs a tape made of composite as raw material in order to produce a composite component from scratch. AFPT GmbH, the sister company of Tikael Composite Machinery BV, is a leading supplier of laser-assisted Automated Fibre Placement (AFP) machines. These machines are used by their customers to produce thermoplastic fiber composite components. The machine consists of an end effector mounted on a robotic system. The end effector is responsible for laying and consolidating the composite tape by using heat and pressure.

AFPT GmbH is a leader on the market for the production of tubular composite structure and it wants to enlarge its capability with the aim of improving the manufacturing of flat composite structures. The goal of this project was to develop a new robotic system in order to manufacture flat composite structures.





CHALLENGES

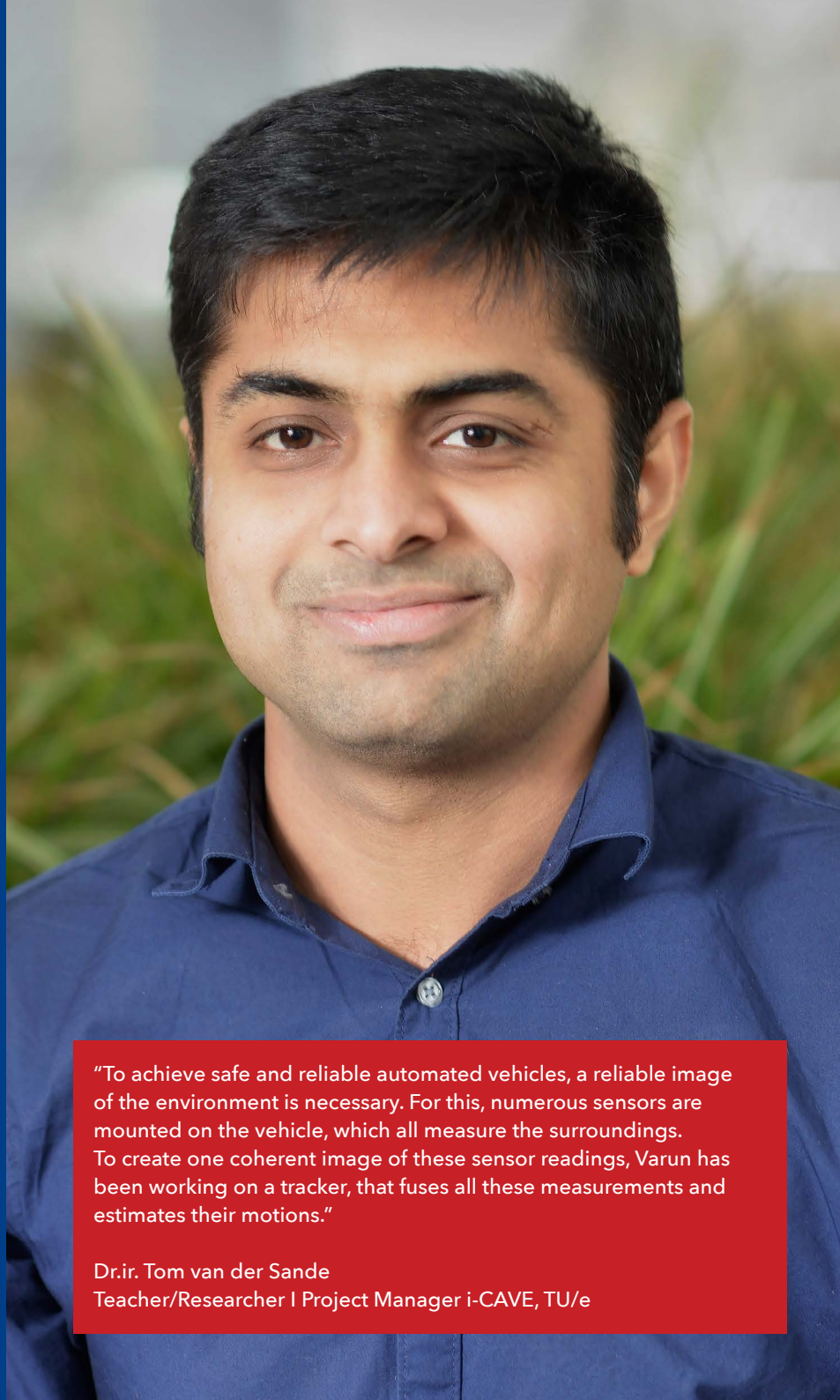
Target tracking is challenging because the number of targets is unknown and is changing continuously, measurement noise is present in sensors and due to the environment e.g. bad weather, the motion of the targets has to be modelled accurately, and the processing has to be done in real-time because the environment is continuously changing since the vehicle is moving most of the time, and a large delay in processing can lead to an accident.

RESULTS

The results show that GNN (Global Nearest Neighbor) data association with the constant acceleration motion model based UKF (Unscented Kalman Filter) and polynomial path tracing are able to track the position, velocity, acceleration, yaw angle and yaw rate of the lead vehicle with reasonable accuracy for a long time at one stretch in a real-world dense traffic situation.

BENEFITS

Target tracking in heavy traffic situations will help in achieving cooperative platooning with SAE level 5 automation and therefore has the potential to improve safety since human error causes more than 90% of road accidents worldwide, and has been shown to increase fuel efficiency since the combined aerodynamic drag forces on the platoon are reduced when the platoon vehicles follow the lead vehicle at a fixed time and distance gap.



"To achieve safe and reliable automated vehicles, a reliable image of the environment is necessary. For this, numerous sensors are mounted on the vehicle, which all measure the surroundings.
To create one coherent image of these sensor readings, Varun has been working on a tracker, that fuses all these measurements and estimates their motions."

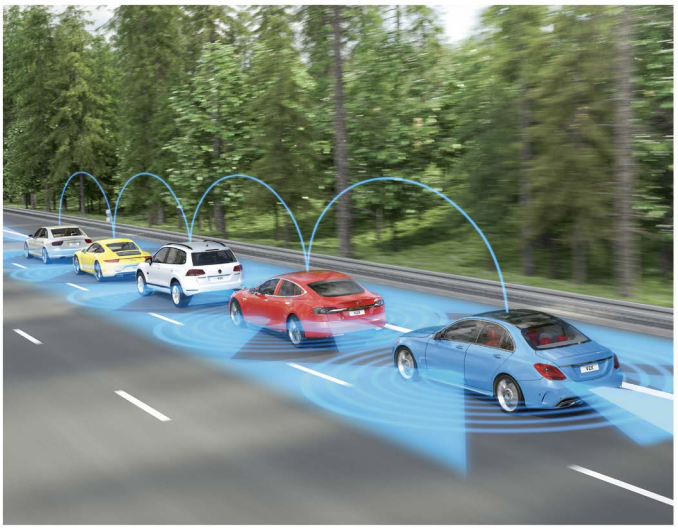
Dr.ir. Tom van der Sande
Teacher/Researcher I Project Manager i-CAVE, TU/e

VARUN KHATTAR, MSc PDEng

Multi-object Tracking Using Sensor Fusion

A cooperative platoon is a group of vehicles moving autonomously in coordination with each other while following a lead vehicle. Each platoon vehicle must continuously track all road users in the FOV (Field-Of-View) of its sensors so that it can select the vehicle directly in front from the tracked road users and follow it.

For this PDEng project, all road users in the FOV of the radars and cameras fitted on an ego vehicle were tracked by fusing measurements from the radars, cameras, GNSS (Global Navigation Satellite System), and the IMU (Inertial Measurement Unit). From these tracked road users, the MIO (Most Important Object) i.e. the lead vehicle was identified. The position, velocity, acceleration, yaw rate and yaw angle of the MIO were tracked using an Unscented Kalman Filter (UKF), Global Nearest Neighbor (GNN) data association, and polynomial path tracing. The design of the tracker was verified by simulations and validated through reconstruction of tracks from measurements obtained by driving in a real-world scenario in MATLAB. The tracker was implemented on an experimental vehicle using ROS (Robot Operating System) and Simulink Real-Time with automotive Ethernet based NXP Cocoon radars, a stereo camera, Linux based NXP Bluebox (an autonomous driving platform with 2 embedded processors and 1 micro-controller), and a Real-Time Target (RTT) machine.



"Andrew's assignment was to investigate the piezo actuation concepts, as a part of the bigger Advanced Long-range Piezo stage (ALP) project (collaboration between ASML and TU/e). With eye for detail, important in sub-nm positioning devices, he mapped the actuator requirements from the application side onto the actuator capabilities, considering a wide variety of operation modes and materials. The result is an actuator concept design, in the sweet spot of the design space linking the control relevant actuator stiffness to mechanic and electrical optimal geometries. The other PhD candidates in the ALP project can use Andrew's insights to come to the overall project goal of a lightweight piezo actuated stage concept."

Ir. Bas Jansen
Mechatronic Design Engineer, ASML B.V.

CHALLENGES

The challenge lies in handling the contradicting stringent requirements and their connections. Hysteresis in lead zirconate titanate (PZT) piezoelectric actuators deteriorates the accuracy, while single-crystal piezoelectric actuators has good linearity but with a small actuation range. Also, the capacitance and mass of the piezoelectric actuator (which increase with the range and force capacity) should be kept small to allow operating at high frequencies and a lightweight design.

RESULTS

The application requirements are analyzed and translated to actuator requirements. A set of design relations are derived to find out the sweet design spots where the mass and capacitance of the actuator are minimized while achieving the range and force requirements of the actuator. Based on the sweet spots, actuator design concepts are developed. The actuator design concepts were shown in simulations to achieve good accuracy.

BENEFITS

The derived design relations present a systematic method that can be used to identify new sweet spots if one of the actuator requirements changes. Also, the identified sweet spots cover a range of actuator stiffnesses that can be selected by other members of the ALP group to fit the other requirements of the application.

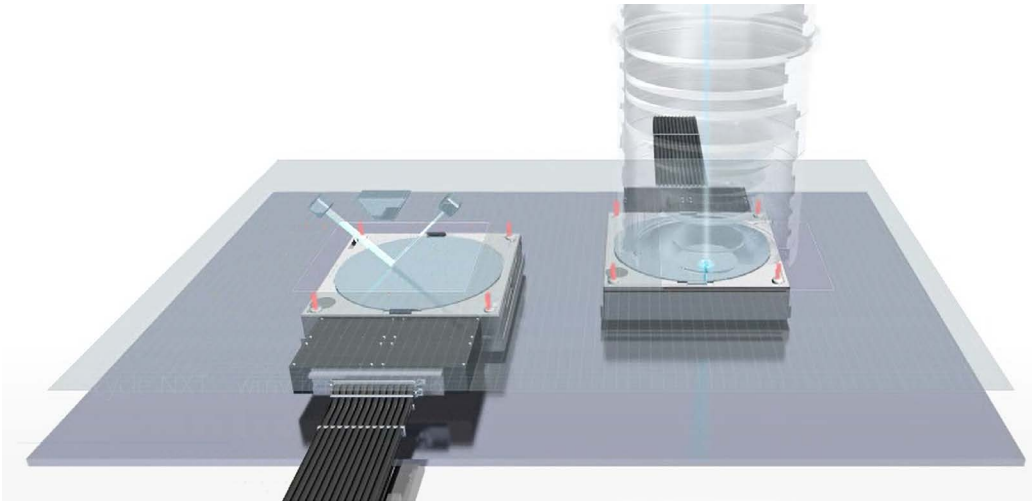
ANDREW WASEF, MSc PDEng

Long Range Accurate Piezo Actuation Concept

ADVANCED LONG-RANGE PIEZO STAGE

The semiconductor industry has been growing in the past few decades. ASML is a leading supplier to the semiconductor industry. Among the products of ASML are wafer scanners. Wafer scanners are used in printing IC patterns on silicon wafers. The wafer scanner includes a wafer stage that is responsible for sub-nm positioning of the wafer under the projection lens. In order to achieve the required accuracy, the wafer stage is actuated through long and short stroke actuators. The short stroke commonly uses Lorentz actuators. A possible replacement for Lorentz actuators are piezoelectric actuators. The Advanced Long-range Piezo stage (ALP) project looks into realizing a piezo actuated stage.

To this end, the piezoelectric actuators need to satisfy the stage requirements including the actuation range and high accuracy in addition to the force capacity, low mass and fast response. Also, some requirements are imposed from other subsystems including the actuator stiffness that should satisfy the control requirements. The motivation for this assignment is to present possible piezo actuation concepts that can satisfy the requirements.



CHALLENGES

To develop Switching Battery Cells Management System (SBCMS) algorithms to be implemented in a Printed Circuit Board (PCB) that utilizes the switching principle for optimal use of solar power and to ensure safe operation of the battery pack and to keep the battery pack balanced.

RESULTS

A Maximum Power Point Tracking (MPPT) algorithm based on heuristics specific to the characteristics of solar arrays Maximum Power Point (MPP) that allowed solar array to operate at almost an MPP at all times was developed. Also, a balancing strategy was proposed and tested on a detailed mathematical model of the energy storage system, which consists of a battery pack model, solar array model, and inverter model.

BENEFITS

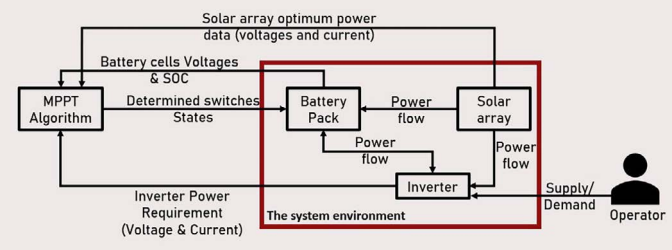
The proposed MPPT algorithm and balancing strategy are practical to be used for optimal solar array and battery pack performance, offering remarkable power conversion efficiency and speed. Also, the project gave insight into the various factors that affect determining the time for switching. The industrial partners can now start testing this technology on their system.

"Within his project, Salih created a simulational platform for investigation of properties of switching battery management system. Despite the complex and challenging character of this task, he demonstrated persistence and determination, which finally led to success. His simulations proved that the concept of Maximal Power Point Tracking (MPPT) by choosing a proper subset of cells from the pack is indeed working. For a practically relevant size of the battery pack, the accuracy of MPPT is very high, and the solar charging efficiency is close to 100%. We are grateful for his achievements in modeling and wish him the best with his future career."

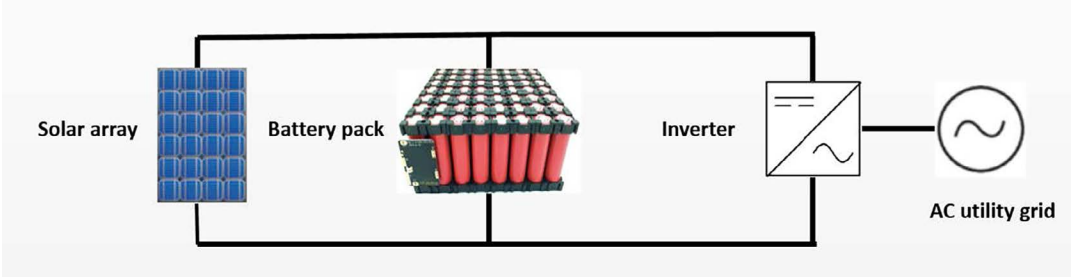
Dr. Dmitri Danilov
Post-Doctoral Researcher, TU/e

SALIH YOUSIF, MSc PDEng

Design and Modelling of Switching Battery Cells Management System (SBCMS) for Solar-Powered Storage Installations



The development of energy storage systems based on lithium-ion chemistry is on the increase, mainly propelled by electric mobility and photovoltaic systems. Generally, battery cells are connected with a galvanic serial connection inside the battery pack. Engineers from Kago Electronics BV proposed switching battery management system where semiconductor switches can shunt cells independently. The switching principle gives the possibility to control the flow of current and the total voltage output of the battery pack. In photovoltaic systems, this switching principle can eliminate the need for a charge controller device which is a critical component in a photovoltaic system. The charge controller device ensures that solar array operates at maximum power and safety of the battery pack. The RVO-financed project 'REgenerative Utility of Saved Energy' (RE_USE) has an aim to demonstrate the possibility of a modular battery pack equipped with the switching battery management system and combined with an array of solar panels. This system delivers a flexible middle-size residential energy storage solution with low cost and the possibility to use second-life battery cells.



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