2017

Innovative technological solutions designed by PDEng trainees

TU Delft Delft University of Technology

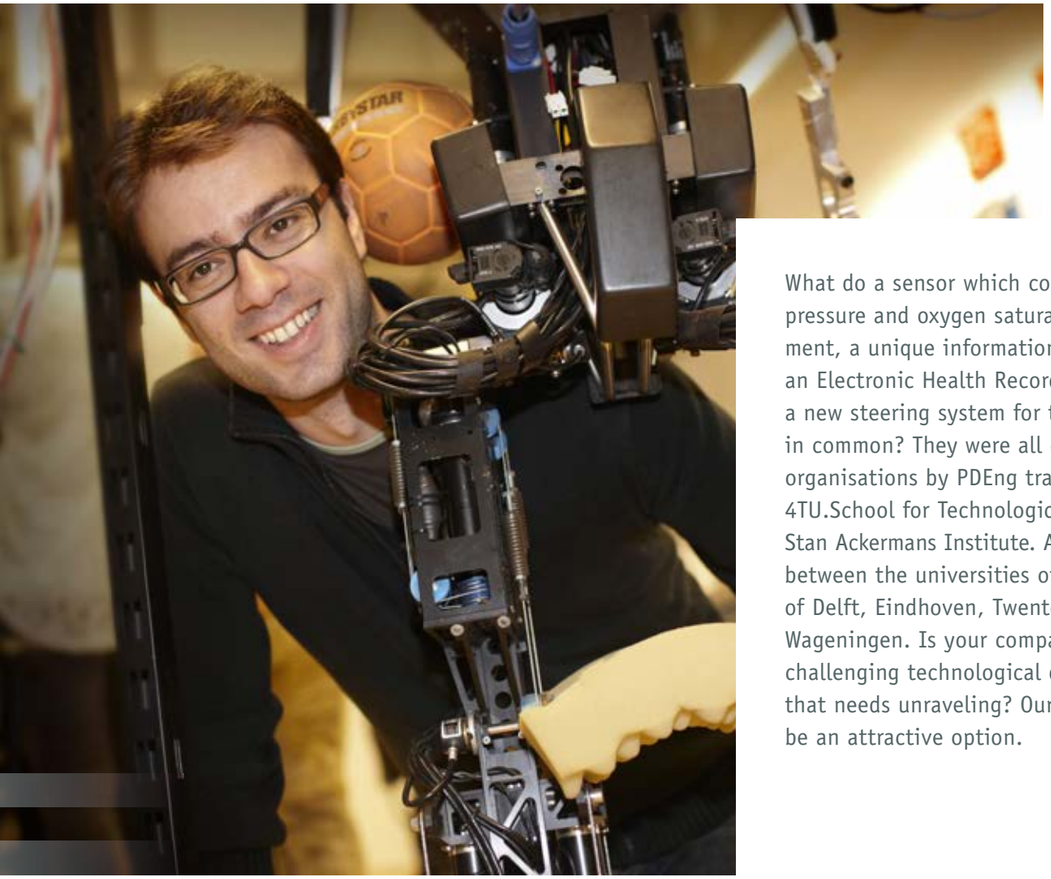
TU/e Technische Universiteit Eindhoven University of Technology

UNIVERSITY OF TWENTE.

WAGENINGEN UR For quality of life

A selection of projects

4TU. School for Technological Design STAN ACKERMANS INSTITUTE



What do a sensor which combines blood pressure and oxygen saturation measurement, a unique information model for an Electronic Health Record system and a new steering system for trailers have in common? They were all designed for organisations by PDEng trainees of 4TU.School for Technological Design, Stan Ackermans Institute. A collaboration between the universities of technology of Delft, Eindhoven, Twente and Wageningen. Is your company facing a challenging technological design issue that needs unraveling? Our trainees may be an attractive option.

Introduction

During a full time, two year traineeship our best MSc students are trained to become a technological designer. After successfully completing the programme they are entitled to use the academic degree Professional Doctorate in Engineering (PDEng). The 21 different programmes all fall within the 3rd cycle of higher education, as do the doctorate PhD programmes.

Putting theory into practice

The trainees spend their first year following a dedicated curriculum, which involves courses, interactive workshops and group and practical assignments. Often in close cooperation with industrial and health care partners. In the second year the trainees carry out an in-company design assignment. University experts act as supervisors, providing state-of-the-art technology, advising on the structure and execution of the project and monitoring that the goals of the project are realised. During the design project, the trainees demonstrate their skills in being able to turn knowledge into innovative business solutions for the high-tech industry or health care sector. In some programmes courses and design project run parallel.

Selection of interesting design projects

To demonstrate the value of the outcome of the PDEng design projects, we've made a selection of the latest design projects for you and combined them in this publication. We hope you enjoy reading about the projects produced by our talented PDEng trainees. For more information about our programmes please visit www.4tu.nl/sai.

With best regards,

Prof.dr. Paul Koenraad
Director 4TU.School for Technological Design,
Stan Ackermans Institute (4TU.SAI)

Company: DAF Trucks N.V.
Project: Developing an environmental model for trucks
PDEng trainee: Evangelos Stamatopoulos

Automotive Systems Design

The automotive landscape, passenger cars as well as trucks, is facing big changes due to the increased use of Advanced Driving Assistance Systems. DAF is faced with many challenges in this respect and one of these is the fact that a reliable and robust perception of the road environment around the vehicle is crucial for the development of fully autonomous trucks.

This project gave insight into the challenges related to defining and developing an Environment Model based on the signals supplied by several individual sensors. An Environment Model was designed, by means of sensor synergy and sensor data fusion, which resulted in a functional proof-of-concept on a prototype vehicle.

Results
A functional prototype that can provide several ADAS functions with important environment information has been created. The employed sensor fusion algorithm combines information coming from several sensors and increases the completeness in the environment perception. The designed Environment Model has proven successful in providing essential environment information to enable the functionality of the Traffic Jam Assist function. Demonstrating the functionality of the Environment Model is a kick-start towards the realization of more sophisticated ADAS functions in the future. For customers this means more safety, comfort and efficiency.

Company: DSM
Project: A model based monolith reactor design
PDEng trainee: Kalpana Samant

Bioprocess Engineering

With each additional year, we are adding one degree to our global temperature. To make a direct impact, we have to innovate, collaborate and implement new solutions. Carbon dioxide or CO_2 is one of the commonly known greenhouse gases whose percentage in the atmosphere is increasing every year. This project aims to use CO_2 -rich gaseous streams (syngas) that can be found in many industries to produce small molecules that can serve as building blocks for further chemical reactions. The existing commercial technologies are decades old and use high temperature and high pressure to convert the gaseous streams into the desired products, which is not very sustainable.

Innovation has come in the form of microbial conversion of syngas using mild reaction conditions. Commercializing this technology requires collaboration between microbiology and reaction engineering. This project aimed to build a mathematical model to provide easier insight into the optimal reaction design.

Kalpana: *"I made a mathematical model simulating a reactor. The model used microbial kinetics and mass and heat transfer models, and was combined with economic evaluations for an optimized process design. I also did a risk analysis of the project outcome was also done which clearly indicated the high price of the reactor and the high operating costs as crucial design decision points."*

This innovative project included a collaboration on many dimensions of reaction engineering, process design and technical and economic evaluation. The calculations for the optimum dimensions of the reactor, a reaction engineering question, were based on the optimum thickness of the microbial biofilm attaching the microbes to the reactor wall, which is a microbiology question. The project also looked at technical and financial considerations to fine-tune the design - a largescale monolith microbial biofilm reactor for gas fermentation.

The next step: verifying the results of the mathematical model and further developing the technology for commercial use, using CO_2 -rich streams to create the building blocks for further chemical reactions.

Company: Keolis Netherlands
Project: Identifying suitable locations for alternative public transport services
PDEng student: Sander Veldscholten

Civil Engineering

Keolis Netherlands is transforming from a classical public transport company, which is organized more or less top-down when it comes to providing public transport, into a provider of mobility services which is far more client, or bottom-up orientated. To make this transformation possible, it is mandatory to invest in knowledge of travel patterns. This PDEng project is about providing a good estimate of the direction and timeslots in which people in a distinct area travel. This information is interesting for a provider of mobility services because when there is enough mass on a corridor, a specific type of public transport can be introduced.
This project has its focus on chances for alternative public transport modalities in areas with a low population density as in these areas regular public transport is highly inefficient. With enough information on travel behaviour in these areas, alternative public transport services can be introduced in these low-urbanized areas such as flex- or rush hour services, neighbourhood operated (mini-) buses or shared cars.

Results
A decision support system is being designed using data on demographics and travel behaviour from different open and closed sources. This data is stored in a data warehouse and processed using data mining and machine learning techniques to generate enriched origin-destination matrices. These matrices will be used to feed a system which dynamically shows travel relations on a map. This system can be used by Keolis to base proposals for new services on.

Sander: *"As a PDEng programme is a co-operation between the university and business, it gives me the opportunity to broaden and deepen my knowledge while conducting a design project which has value for Keolis. I take full advantage of the possibilities to learn more about data processing while I'm designing a system which has the potential to enhance society with tailor-made mobility solutions."*

Institute: Medisch Spectrum Twente / Technische Universiteit Eindhoven
Project: Designing an information model for a new electronic healthcare record system
PDEng student: Marjolijn Elsinga

Clinical informatics

Introduction
More and more hospitals use Electronic Health Record Systems to register patient information. In preparation for the implementation of a new Electronic Health Record, Medisch Spectrum Twente requested an information model that is based on both the care process and the principle of clinical reasoning to guide a future implementation.

Methodology
The chosen design methodology consists of a combination of literature, international standards and architectures and the principle of clinical reasoning, which is matched against the work experience of MST caretakers in interactive meetings with the dedicated project team.

Result
The project resulted in four deliverables:
1. information model containing 44 information objects, including their definition, structure and interrelationship,
2. framework for use, describing criteria and principles for using the information model,
3. advice for organizational structure for optimal start of usage, adaption and maintenance of the information model,
4. approval of the information model from the responsible internal committee.

The project was successfully executed and meets all the pre-selected requirements. Furthermore, a new, unique approach for designing was refined during this project, which made it possible to discuss an information model on both abstract and detailed levels between information experts and caretakers. Overall the project was perceived as very valuable by all project participants and has helped to create more knowledge and awareness about information modeling throughout the organization.

Company: BioSolar Cells
Project: Artificial leaf - producing hydrogen with sunlight
PDEng trainee: Mercedes Victoria Garcia

Chemical Product Design

Hydrogen, if produced from clean and abundant sources, has the potential to solve the concerns around security of energy supply, climate change and local air pollution. Photo-electrochemical (PEC) water splitting is a promising technology: using sunlight to split water to obtain hydrogen. This technology is also called artificial leaf, because it resembles the photosynthesis process. Although it is still under development, the technology has attained a sufficient level to justify starting to investigate its implementation on an industrial scale. This PDEng project for the BioSolar Cells consortium aimed to design a modular PEC water-splitting device that could be on the market by 2020.

Mercedes: *"We created and investigated various device alternatives using a step-wise design methodology. Each round, we evaluated the options according to previously established technical, economical, safety and sustainability criteria. We finally proposed a device consisting of a back-illuminated tandem photo-electrode with a metal counter electrode for further research and development. Designing a commercial-scale device also shed light on practical issues that need to be resolved before this technology can be marketable – we need to develop anion exchange membranes and protective layers to improve the stability of the semiconductor photo-electrodes."*

The economic feasibility of a hydrogen production plant using this device would have a potential cost below the target of 6 $/kg H_2. This device itself can be manufactured with commercially available components and manufacturing processes, at an estimated cost of ~70 $/m^2. A sustainability life cycle assessment (LCA) showed that the energy payback for this system would be shorter than 2 years. With these numbers, it can be concluded that the conceptual design could succeed in the market, providing a safe and environmentally friendly process for hydrogen production.

Company: Edwards Lifesciences
Project: Designing a sensor which combines blood pressure and oxygen saturation measurement
PDEng student: Geert Claassen

Design and Technology of Instrumentation

With increasing pressure on hospital staff and budget, workflow optimizations are needed. Combining blood pressure and oxygen saturation measurement into one sensor would help to save time in application and removal of sensors. The goal of this project was to investigate the feasibility of the simultaneous measurement of blood pressure using the volume clamp method and arterial oxygenation using pulse-oximetry with one sensor.

Approach
Two prototypes were designed and manufactured. The first prototype measures arterial oxygen saturation only. The second prototype is a first implementation of a combined sensor, including a signal processing algorithm. The function of both prototypes has been investigated by verification experiments. The first prototype functions as expected. The second prototype has not yet reached full functionality but provided valuable information and input for product improvements.

Results
Feasibility experiments have been performed on a small group of healthy subjects. The results are promising, and provide the initial steps towards feasibility. This project provides a good foundation to continue the investigation, involving more subjects and improved prototypes.

Company: PAQUES BV
Project: Designing a process for recovery of acids from fermented waste water
PDEng student: Chiel van Beek

Energy and Process Technology

As the global awareness for the need of sustainable and renewable processes increases together with the increasing concern on the depletion of (easily accessible) fossil resources, new routes for the production of bio-based chemicals is researched. One of these routes is the production of bio-based chemicals via fermentation. Different groups of bio-based chemicals can be produced through fermentation such as volatile fatty acids (or VFAs). VFAs are versatile carboxylic acids, such as acetic acid and butyric acid, which van be utilized in the production of bio-based plastic, bio-energy and are even used in the food industry. Synthesis of valuable chemicals from the VFAs starts with the production and purification of the VFAs in an economically viable process. As the fermentation broth has a complex composition which contain different components like salts (Cl-, K+, Na+, and SO42-) and acids (Acetic acid, Propionic acid, Butyric acid and Lactic acid) in a diluted solution (≈0.25wt% for each acid), separation and purification of the VFAs is challenging.

An economically viable process requires an efficient solution for the separation of the VFAs, the research in the extraction and purification of VFAs still continues and this is where the current PDEng-project comes into play. As part of a larger research project of the companies PAQUES BV and NWO the recovery of VFAs from fermented waste water and the conversion of VFAs is researched by PhD students at the University of Twente (recovery) and the University of Utrecht (catalytic conversion). The goal of the PDEng project is combining the research on extraction and conversion into a working technology in the form of a continuous working bench scale set-up in which extraction of VFAs is combined with the conversion of the VFAs.

Chiel: *Translating fundamental research which is done in batch wise to a working continuous process is challenging. My process is for that matter unique as it requires experiments to get additional process parameters which can be used for the development of the process. I have learned a lot on how to interpret and translate experimental data and what is needed to design a process.*

Company: 2M Engineering
Project: Extracting heart rate from a contactless bedsensor
PDEng student: Mahta Fadaeinia

Design of Electrical Engineering Systems
Track Healthcare Systems Design

Heart rate is a physiological parameter that is used in a wide range of clinical and ambulatory healthcare applications. Electrocardiography (ECG) is considered as the golden standard method for heart rate monitoring, however, this method is burdensome for the patients as it includes electrodes on the skin. Within the Bedsense project, a newly developed, extremely sensitive pressure sensor placed under the mattress to monitor even the smallest changes in pressure during sleep. The benefit compared to other solutions is that the user has no wires or clips attached to the body, allowing undisturbed sleep also over longer periods. This Project aims at extracting heart rate from the Ballistocardiography (BCG) signals measured by the contactless bed sensor during sleep and compare it with the golden standard.
The designed algorithm is tested on 8 hours full night sleep recordings of 5 sleep disorder patients in Kempenhaeghe epilepsy center. Experiments show an average beat to beat accuracy of 92±7% compared to the golden standard. The average sensitivity is 81±2%.

This project reports on an early observations of the practical use of Bedsensor system in a hospital setting for the monitoring of patients with sleep disorders. We believe that these observations, albeit preliminary, highlight some key opportunities (as well as challenges) of such monitoring, and thus might benefit the BCG community.

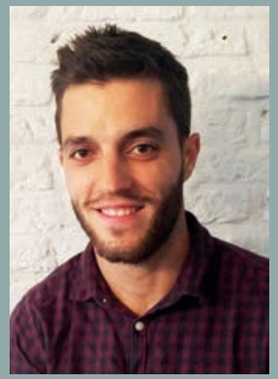
Company: FEI Company
Project: Embedded electronics for data-intensive control
PDEng student: Garbí Singla Lezcano

Design of Electrical Engineering Systems
Track Information and communication Technology

For the next generation of its systems, the customer pursues further correction of disturbances that affect image quality and control accuracy of their systems. The use of advanced control approaches is the most promising route to achieve this goal. The latest generation of embedded systems enables data-intensive control, in which the sensing information is obtained after using a computationally intensive process, such as image processing. This information is then used as input for the control algorithms and can be combined with traditional sensors like encoders or accelerometers.
To investigate the applicability of data intensive control in their systems, the customer requires a platform that can be used for prototyping. This platform must enable data-intensive control and comprise a real-time network able to meet the strict requirements of real-time control applications.

Design approach
A platform design and real-time network are proposed through research of technologies in relevant fields and industries. The final design and implementation are a tradeoff between various requirements of stakeholders, platform flexibility and risks. The platform implementation require the application of knowledge of disciplines such as FPGA design, control theory, real-time systems or PCB design.

Platform to boost innovation and research
The platform was validated by the successful implementation and execution of a relevant use case on one of the customer's prototyping systems. This demonstrated that image-based control in their systems is feasible, and that the platform enables the exploration of novel use cases. It enables the application of data-intensive control to improve system performance even further.



Company: ASML
Project: A design for spare parts stocking under demand uncertainty
PDEng student: Neda Javanmardi

Industrial Engineering

ASML is the world leading manufacturer of lithography systems for the semiconductor industry. ASML systems are of such importance in the process of the customer that each hour down-time has significant financial impact. Therefore ASML has very strict service level agreements (SLA) with customers that require very low down time.

To meet the SLA, spare parts are stocked at warehouses across the globe. The stocking decision for systems in the "New Product Introduction" (NPI) phase is a challenge due to the demand uncertainty.

In this project we design a new stocking model for indicating the stock levels for the spare parts of the systems in the NPI phase. The new stocking model includes three different modules: pre-process module which considers the criteria that play a role in stocking decisions, failure rate module which is based on Bayesian approach to capture the effect of demand uncertainty and inventory module which minimizes the total cost of stocking while satisfying the customer SLA. As a result of this project we provide a tool prototype to be used by the planners at ASML for making the stock decisions.

Company: Broshuis BV
Project: Improving the steering system of trailers to reduce maintenance costs
PDEng trainee: Hendrik Spoelhof

Maintenance

Broshuis BV is a well-respected manufacturer of trailers for heavy and special transport. In this field of transportation the challenge is to use every trailer for moving both heavy and large size goods. Related to the current trend of replacing fossil power plants by for instance wind turbines, one can think of the blades, the tower sections and the top section which is housing the generator. The sector therefore demands trailers that can be used both effectively and efficiently.

The solution is found in trailers with a low loading floor, multiple axles of which most are steered and an extendable chassis. Due to regulations, the steering of the axles is achieved by a hydraulic-mechanical system. This system does not change when the chassis is extended, both enhancing reliability and preserving ease of operation.

In recent years, the industry has adopted independent suspension systems as higher axle load are allowed for trailers with such a suspension system. By upgrading the classical steering system to better suit the independent suspension system, such trailers show improved steering performance. However, due to the higher axle loads, higher lateral forces occur. This causes the mileage of the tires and lifetime of bearings to be similar to traditional trailers.

Maintenance on tires and bearings means downtime of the trailer, so this has to be decreased in order to achieve the desired increase in transport efficiency. The goal of the assignment is to further improve the steering system so that the maintenance costs and maintenance effort can be decreased.

To achieve this goal the behavior of the trailer during transport is investigated. First, the influence of vertical movement of the suspension is analyzed. Second, cornering at various speeds is analyzed and how this is influenced when the chassis of the trailer is extended. Recently trailers with an upgraded steering system addressing the first part have been delivered to the customers. Currently the second part is being addressed using vehicle dynamics and the design improvements are being created.

Company: Maritime Institute of the Netherlands (MARIN)
Project: Optimizing the design of Liquefied Natural Gas cargo and fuel tanks
PDEng trainees: Panagiotis Efstathiou, Ashwin Fernandes, Vladimir Novakovic

Process and Equipment Design

In recent years, the application of Liquefied Natural Gas (LNG) as fuel for ships and trucks is gaining increasing attention. As a result, a relevant market is currently emerging. However, significant investments are needed in the distribution sector for LNG (fuelling stations, feeders, carrier ships), and in new technologies to run ships and trucks on LNG. The Sloshing of Liquefied Natural Gas (SLING) project focuses on the reduction of costs for ships through optimization of the design of LNG cargo and fuel tanks.

Panagiotis: *The focus of my project was the design of a bubbler setup, which will be used in a series of aerated liquid impact tests. This involved detailed design of the gas feed system to the bubbler, which was a significant technical challenge, when taking into account the broad temperature and pressure requirements for the tests.*

Ashwin: *The objective of my project was to perform the safety assessment for the assembly, and to design and realise the risk reduction measures so as to comply with applicable European and Dutch directives. The first phase consisted of identification of the deliverables and recruitment of the personnel needed for the safety activities. The second phase involved performing risk assessments at the assembly level. The third phase involved the implementation of safety measures.*

Vladimir: *The overall goal of my project was the design of a high-speed liquid impactor for studying the effect of free surface instabilities and liquid and gas compressibility on sloshing impact loads. The scope includes a conceptual design of the actuator of the impactor assembly consisting of its drive, control system, feedthrough with sealing and impactor guidance that should operate under a wide range of temperature and pressure conditions. The main challenge of the project was the choice of suitable technology and implementation of the technology in the testing environment.*

Company: SABIC
Project: Development of a Pre-polymerization Reactor for Polypropylene Manufacturing
PDEng student: Konstantinos Papanikolaou

Process and Product Design

Polypropylene (PP) is a thermoplastic polymer with a very wide range of applications, from grocery bags to automotive plastics. The great aptness of PP is rightfully reflected by the global production of approximately 54 million metric tons (MMT) in 2014, which is expected to further expand to 70 MMT till 2020.

As one of the world's top PP manufacturers, SABIC endeavors to advance promptly by building solid foundations towards more innovative and energy-efficient PP production processes. The Achilles' heel of the gas-phase PP production processes operated by SABIC is the formation of catalytic fines in the main polymerization reactor. These are extremely small and active catalytic particles formed upon the uncontrolled fragmentation of the process catalyst owing to exposure to intensive process conditions. Reactor fouling, loss of active material, formation of lumps and subsequent reactor clogging are some of the harmful events caused by the catalytic fines, leading in turn to increased operating and maintenance costs, and on many occasions to the emergency shutdown of the unit.

To mitigate these negative effects a pre-polymerization step is applied prior to the main polymerization, preparing the catalyst in a way that will prevent the problems described above. In this project a novel pre-polymerization reactor pilot plant was designed, modeled, scaled up and evaluated in terms of process economics. An entirely new design concept was introduced and the reactor model proved to be successful with a maximum relative error of 12% between model and experiment. In addition, the economic evaluation confirmed the project's feasibility, with breakeven two years after the reactor installation and a minimum internal rate of return (IRR) of 29%.

Company: Leiden University Medical Centre (LUMC)
Project: Making the Aeration, Breathing and Clamping approach as safe as possible for babies
PDEng student: Ing. Alex Vernooij

Qualified Medical Engineer

After the birth of a term (gestational age 37 weeks or more) baby it is common practice to wait a couple of minutes before clamping the umbilical cord. This allows the blood in the placenta to flow to the baby. The benefits of this have already been known for many years. A lot of premature babies (less than 35 weeks of gestation) need resuscitation directly after birth. Therefore the cord is cut quickly and the baby is transferred to a neonatal resuscitation table. A new resuscitation table (Concord) that allows both late cord clamping and immediate restitution was required.

We first investigated the requirements, performed risk analyses and developed a new Standard Operating Procedure (SOP). We designed and built the Concord that allows the neonatologist to resuscitate the premature baby according to the international guidelines without clamping the cord.
A premature baby can now benefit from late cord clamping and immediate resuscitation. Besides that, mother and baby do not have to be separated from each other.

A first clinical study (safety and feasibility study) is has been performed with the Concord. With partners, the business potential of the Concord has been validated and a new company (Concord Neonatal) has been started with this patented invention.

Company: Royal IHC
Project: Designing the perfect machine for the replacement of sewer systems
PDEng student: Ruud Spoor

Robotics

In the Netherlands alone, there is 111.000 kilometers of sewer system buried underground. Sewers are in general long lasting systems with some over a century old. These systems deteriorate over time and have to be replaced at some point. Sewer systems in the Netherlands are buried underneath streets and roads. Streets are broken up for extended periods of time to dig for old pipe sections and replace these sections with new pipes.

The traditional method of replacement is called trenched replacement. The closing of streets and roads with traditional methods causes great inconvenience for traffic and civil life. Especially in city centers the inconvenience is high due to limited space and high amounts of traffic. Sewers can be replaced without breaking up streets and roads completely. These methods are called trenchless replacement and solutions do already exist like pipe bursting and pipe reaming.

Ruud: *"Trenchless replacement methods do already exist for a long time. They are however not used that often in the Netherlands and are limited in their capabilities. Furthermore, there has not been any major innovation in the trenchless replacement market for over thirty years.*
In collaboration with Royal IHC, we started a project to solve difficulties of existing trenched and trenchless replacement methods. It is my job as a PDEng student to investigate and develop a new innovative prototype for the trenchless replacement of sewer pipes. Instead of improving existing replacement technology, we decided

to start system design from scratch. The municipality of Rotterdam was contacted for customer requirements and delivered a challenging use case for an ideal replacement machine based on an existing piece of sewer system in the center of Rotterdam.
It is our goal to develop an innovative and perfect replacement machine to replace sewer systems directly beneath your feet without you even noticing."

Company: SEAC
Project: Bringing Building Integrated Thin-Film PV to the market
PDEng student: Finn Vossen

Smart Buildings and Cities

Today, many people think solar panels are only ugly, grey rectangles. But thin-film photovoltaic (PV) technology can be so much more: flexible, transparent, and in any colour and size you might want. In the PV OpMaat project, we're working to get this technology to the market. It's not easy: people want well-known, efficient and proven technology, and are hesitant to try something new. I'm connecting the world of construction and the world of PV to build demonstrators so people can see the technology in real life.

The Interreg V *'PV OpMaat'* project aims to develop three demonstrators that show promising applications of Thin Film Photovoltaics in building elements. My PDEng project supported the 'product and process development' in the PV OpMaat project while securing the inclusion of both technology push and market pull factors in the development of the Thin Film technology. In order to reach this goal the six-step Method of Design Thinking and theories regarding Technology Transition were selected to be implemented in the PV OpMaat project and evaluated on their effectiveness. Based on insights that followed from understanding Thin Film technology and observing the market, a design challenge was defined. This resulted in the ideation of three demonstrator concepts:

1. Super flexible, custom-sized Thin Film foil from the roll on lightweight substrate for building applications
2. Thin Film Solar glazing in different transparencies for façade application
3. Custom sized and coloured Thin Film panels for solar façade application. The third concept was elaborated on in the prototype phase and tested with the help of writing a business plan.

Company: Philips Research
Project: Data Linkage Architecture for Population Health
PDEng student: Ana Kostadinovska

Software Technology

Linking data of individuals from various sources can be very insightful. Linked data can provide more information than the information contained in every data source separately. Research scientists in Philips are trying to perform data linkage in order to combine data of patients from different sources. By linking data from different sources, the researchers aim to improve the prediction accuracy of the developed prediction or risk models as well as perform analysis with access to complete data.

Various use cases of data linkage reside within Philips Research but no unified approach in data linkage exists. Every project develops its own solution that is mainly used in the project only. The data linkage cannot be performed by the researchers since they are not allowed to access identifiable information of patients. Hence, developing a solution requires laborious manual effort since it requires technological skills which might not be present with the people from business units, who have access to the data and are performing the data linkage. The goal of this project was to deliver a system that provides the data linkage functionality and is a solution for the challenges and needs of the Philips data linkage use cases. In order to be used as a data linkage solution in various projects within Philips, the system should be accessible for everyone in Philips. Being deployable on the Philips HealthSuite Digital Platform (HSDP) was another goal of the project as a way to provide the data linkage system to the end users.

A data linkage system was developed that provides the data linkage functionality and can be used in every Philips data linkage use case. The data linkage system is compliant with the HSDP, which makes it accessible for every project in Philips that has a need of data linkage.

Ana: *"The Software Technology program gave me great opportunity to experience challenges and benefits that the work in industry brings. Immersing my knowledge and designers skills into practice, I faced new challenges that helped me grow both professionally and personally. Being part of a Phillips Research team, allowed me to understand, design, and implement the data linkage needs of data scientists and contribute to the mission of improving lives."*

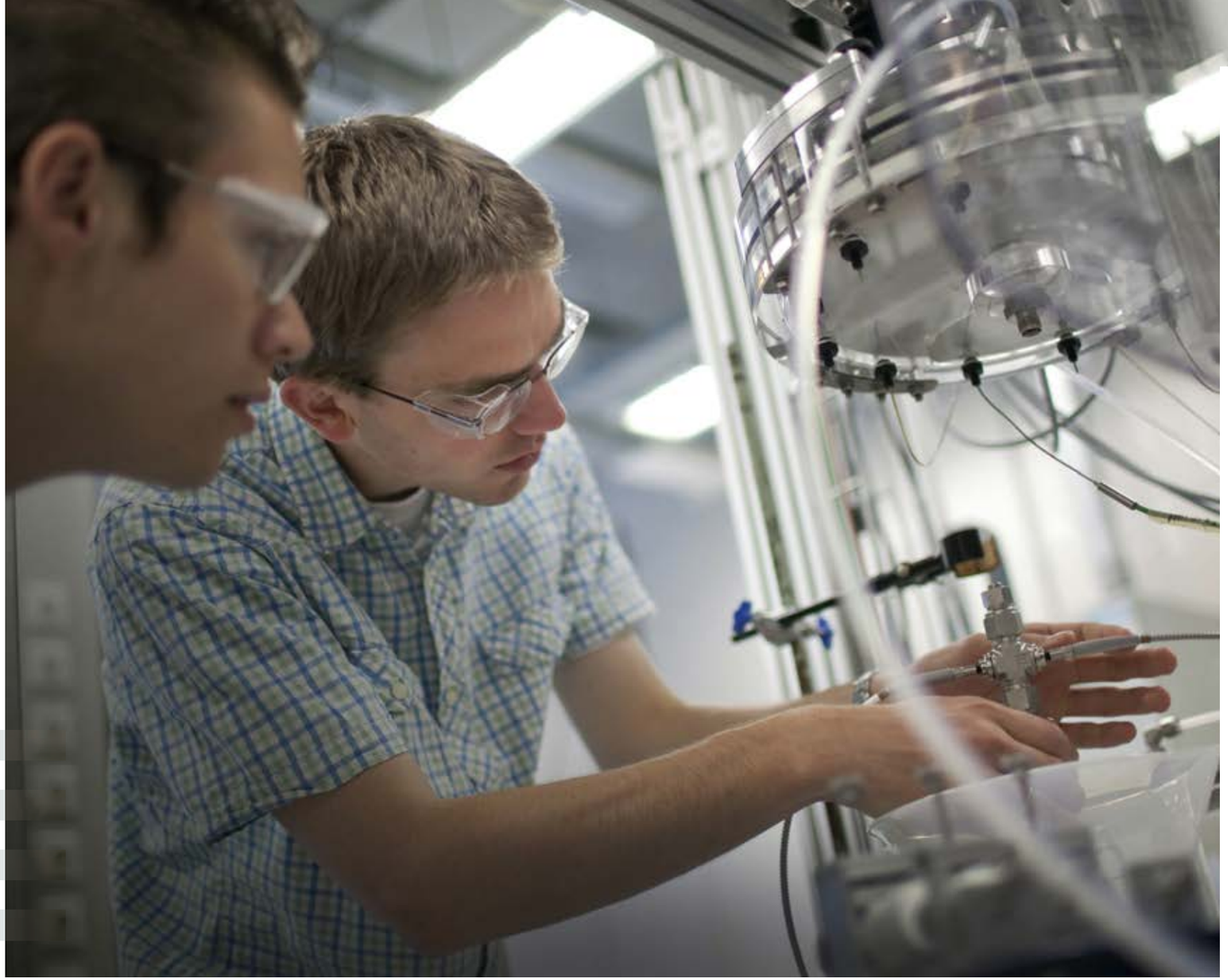
Institutes: Kempenhaeghe en SEIN Sleep Centers
Project: Narcolepsy Companion App
PDEng trainee: Jan de Wit

User System Interaction

Narcolepsy is a chronic sleep disorder with a broad range of symptoms. Together with Kempenhaeghe and SEIN sleep centers, we developed a working prototype of a companion app designed to run on patients' smartphones, to increase the frequency with which they are able to report on the way they have been experiencing their symptoms. Rather than simply creating a digital version of the existing paper questionnaire, the entire act of registering symptom severity has been redesigned to take optimal advantage of the mobile phone platform. Because it is designed to be used frequently and long-term, care was taken to ensure that registering symptoms requires low effort. One of the main challenges with these types of systems is getting this long-term commitment, when there is no direct payoff for the patient. Fortunately, modern platforms such as smartphones and watches allow us to schedule reminders to try and keep people engaged.

Next to the app itself, a dashboard was developed as a tool for doctor-patient meetings, where for a particular patient all the reported symptom severity ratings can be shown through time. The idea is for the doctor, together with the patient, to discover topics of discussion and perhaps use the self-reported data as a guideline to inform treatment decisions.

Jan: *"It was great to see how much we could learn about the user experience of the app just by looking at the data that was being logged. For example, there seemed to be different patterns of use. Where some people would stick to daily use, others would take frequent breaks of a few days, even when they were being sent reminders. As a secondary feature, we introduced the ability to leave open comments in the app, kind of like a diary. This actually became the main functionality for some users, giving us a lot of insight in the form of features or symptoms that were currently missing in the app and qualitative information that could help to create personas to inform our future design decisions."*



The Professional Doctorate in Engineering (PDEng) programmes in brief

Programme	Founded	Graduates 1988-2016	Location
Industrial Engineering*	1988	349	TU/e
Design of Electrical Engineering Systems (Track Information & Communication Technologie, Track Healthcare Systems Design)	1988	251	TU/e
Process and Product Design	1989	405	TU/e
Mathematics for Industry**	1989	305	TU/e
Software Technology	1990	421	TU/e
Design and Technology of Instrumentation	1991	158	TU/e
Process and Equipment Design	1991	188	TUD
Bioprocess Engineering	1994	131	TUD
Architectural Design Management Systems**	1996	93	TU/e
User System Interaction	1998	302	TU/e
Automotive Systems Design	2011	36	TU/e
Smart Buildings & Cities***	2011	26	TU/e
Energy & Process Technology	2011	6	UT
Robotics	2011	5	UT
Civil Engineering	2011	9	UT
Clinical Informatics	2012	43	TU/e
Chemical Product Design	2012	7	TUD
Healthcare Logistics	2014	-	UT
Maintenance	2014	-	UT
Qualified Medical Engineer	2014	11	TU/e
Data Science	2016	-	TU/e

** Before Logistics Management Systems / ** These programmes are being built down. The current trainees will be supported during their finalisation of the programme in order to receive the PDEng degree. / *** Before Smart Energy Buildings & Cities*

The 4TU.School for Technological Design, Stan Ackermans Institute offers two-year post-master technological designer programmes.

The institute is a joint initiative of the four universities of technology in the Netherlands: Delft University of Technology, Eindhoven University of Technology, University of Twente and Wageningen University.

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