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EDITORIAL

Connecthor

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Editor in chief: Pauline Hoen

Layout editors:

Margot Emke Birgit van Huijgevoort Stijn van Himste Jeroen van Oorschot

Editors:

Elwin Hameleers Esmee Huismans Suzanne Kuijlaars Mark Legters Chigo Okonkwo Fer Radstake Mohsin Siraj Lisa Teunissen Jan Vleeshouwers Rabia Zainab Syeda

Cover:

InMotion electric race car Photo by: Gerlach Delissen

Printer: Schrijen-Lippertz

Editorial correspondence: Connecthor Eindhoven University of Technology

Groene Loper 19, Flux P.O. Box 513 5600 MB Eindhoven

(040) 247 3223, connecthor@tue.nl

Web: http://www.thor.edu http://www.tue.nl/ee

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inally, summer has arrived in the Netherlands; for most of us holiday time, to recharge our energy levels. Before the most of us go off to enjoy our well-deserved vacation time, we hereby present to you the "must read" of our Department, the new Connecthor.

If you are looking for inspiration for an internship abroad, please have a look at the article by automotive student Wilco Pesselse about his internship in South Korea. Further, we bring an article written by Ton Koonen about optical wireless communication using steerable beams of light. We also added a new item to the Connecthor to share with you some insights and humor of remarkable examination work.

We hereby take the opportunity to introduce and welcome two new student editorial board members to our team: Stijn van Himste and Margot Emke. In this issue they introduce themselves to you. At the same time, we have to say goodbye to Suzanne Kuijlaars. Suzanne, thank you for your much appreciated contributions to the Connecthor over the years.

The Connecthor editorial board has positions open for creative and enthusiastic employees of the Department of Electrical Engineering who are interested in joining us to make the Connecthor magazine. Up for a new challenge? Please contact us! If you have ideas for upcoming editions, please contact us via connecthor@tue.nl.

We hope that you enjoy reading this new edition.

The Connecthor editorial board



Master association Eir A new master association in the area of care and cure is starting. Read all about their plans for next year on page 10!



Did you think you were good at making summaries? See page 23 for an extreme one. and a lot of beers were tasted.

CONTENT



See page 28 for the experiences of an intern-

02	Editorial
04	Board Issues: New research direction
	in Electrical Engineering
05	From the President
06	Introducting new editors
07	News
07	Inauguration of "Leap into the deep"
08	Whose desk is this?
08	Goodbye Femke Verheggen
09	WIE Pub lecture
10	'Master association' Eir
11	Phew, a job interview
12	Robust optimization for oil recovery
14	Bosch excursion
15	Icons of EE: Edwin Howard Armstrong
16	Shell: a world of opportunities
18	InMotion
20	Photo page
22	Intimate technology
23	Remarkable examination work
24	ASML: Where technological progress
	had far-reaching benefits.
25	Superconducting electromagnetics
26	Paris holds the key (to your heart)
28	Internship in Korea
30	Mythology: Viking encryption – the
	Røk rune stone
31	Ivaldi OHD
32	Optical wireless communication
34	ODIN trip to Belgium
36	Book my space
37	Two 3E-Royal Smit BSc Awards
38	Puzzle
39	Column: Let me help you get bright



ODIN visited Belgium. To a factory where glassfiber connectors are developped and made,

IDEPARTMENT

New research direction in Electrical Engineering

By: Prof. dr. ir. Bart Smolders



here is a broad consensus within our department that we should maintain our wide research scope in the domain of Electrical Engineering, currently covered by our nine capacity groups. In this way we can be the prime research partner for industry, research institutes and other societal organizations. This also allows us to offer a broad range of advanced technical courses to our future students. Nevertheless, we should continuously seek for new emerging topics. Stimulated by the fact that we need to recruit more than 30 new scientific staff members in the upcoming years, we started a strategic discussion in our department on future research directions. As part of this process a large symposium was held on January 19 in our Flux building, with in total more than 200 participants from academia, research institutes and industry. The organization was a joint activity with our colleagues from Delft, Twente and the IEEE Benelux section. Four keynote speakers from various areas tried to make a sketch of the domain of Electrical Engineering in the year 2050. Next to this, a panel discussion was held with experts from industry. Some relevant trends and emerging topics that were mentioned during the symposium are:

Moore's law is coming to an end. According to Roberto Saracco, chairman of IEEE Future Directions, this already happened in 2013. Future technology development will focus on "More-than-Moore", in which integrated photonics and special semiconductor technologies for mm-wave/ THz applications are just a few examples. In addition, power electronics is seen as a crucial technology in smart-grids, DC-grids and future electric transportation systems.

Major breakthroughs in electrical engineering are also expected to come from multidisciplinary projects, for example by cooperating with material scientists or with medical specialists. Some very nice examples that were mentioned several time are bio-based materials, artificiallyengineered materials, bio-electronics and the electronic brain.

The panel also discussed our future study program. The general opinion is that our department should educate specialists who master the context in which they operate; we should not educate generalists that lack in-depth knowledge. System-level thinking is important and should be addressed within the study program as well. However, training real senior system architects requires time and (industrial) experience.

More information, including slides from the keynote speakers can be found on our website: https://www.tue.nl/universiteit/faculteiten/ electrical-engineering/onderzoek/onderzoeksprofiel/symposium-ee-2050/

I would like to invite you all to actively contribute to our strategic future directions discussion in the next months. You can do this by proposing new emerging topics and by helping us to find new talent to realize these new research areas. Discuss this in your capacity group or send me directly an email with your input. Your input is highly appreciated!

Bart Smolders

a.b.smolders@tue.nl

From the President



Spring has come around and time is going fast. Flowers are sprouting on our roof terrace, the third exam period is already over, our members are playing games on floor six and even more members are already studying for the fourth quartile. To make this time of year even busier, the cases for the study tour to Russia and South Korea have kicked off, giving all participants something extra to do. For me time is also passing by quickly. The first moment I realized that this year as the President of Thor was already half way done was the skiing trip to France.

Last February, during the carnival break, the first skiing trip was organized by our new committee the SnowCo, short for Snow Committee. The trip was to the lovely village of Flaine in France, located at an altitude of 1600 meters. A great place to go for a skiing trip. Flaine has three sectors. We were stationed on the highest plateau of the sectors, named Forêt. Here we rented two apartments for the group and enjoyed ourselves with a week of skiing. Every morning we got up early to enjoy the snow and mountain winds. It was great and we all had loads of fun! The trip is even captured on camera and will be available on Thor's YouTube channel in a few weeks.

As time flies and our time as a Board is coming to an end, a new Board has to be chosen. The search is going well and at this moment we have more than ten interested members for the Board of 2017-2018. It has been a while since there were this many people interested in becoming a Board member of Thor! Of course we are very happy to see so many people wanting to do something extra for our association. But this of course also poses the challenge of who to select. Luckily we have a large group of former Board members who are happy to help in solving this challenge.

Another thing that reminded me of the speed at which the time moves was the fact that we already started making preparations for the introduction week. The weekly meetings of the TIC, the Thor Introduction Committee, started again. All the rough ideas they came up with over the last months are shaped into an introduction week. We hope that this will be one to never forget! Every year we give the

ASSOCIATIONI



freshmen a fantastic week in which they get to know the university, the city of Eindhoven and Thor. Next to this we hope to make them enthusiastic to become an active member at Thor.

For now the daily routine continues and that means helping members with all their questions, organizing all sorts of activities for educational purposes and for fun, and doing the work that is asked of me. As my workday comes to an end, I am going to enjoy a nice cold beer in Het Walhalla while digging up all the stories we already collected during this great year as Board members of Thor. Digging up stories on your own isn't fun of course, but with my fellow Board members with me I'll enjoy myself. So for now: hold on just a little more and it will be summer, after which I'll be back to give you another nice story to read in this fantastic magazine.

Veel gedonder!

Lester Manders President of Thor

DEPARTMENT

Introducting new editors

ev! My name is Margot Emke and I am a second year student of Electrical Engineering. As of this edition, I will be joining the editorial board of the Connecthor. For the last two years that I have been a student at Eindhoven University of Technology, I have enjoyed finding out about all research that is In my next years as a member of the carried out within the department through this magazine, as well as reading about fun and educational activities that are organized by Thor.

I have been an active member of study association Thor for the past two years and have enjoyed both participating in and organizing activities with my fellow students.

ello! My name is Stijn van Himste and I am a second year Electrical Engineering student. I will be joining the editorial board of the Connecthor starting this edition. It always intrigued me to know more about my close environment and what is happening around me. I think it is also good and fun to know what's going on and therefore I want to do my best in making this a great magazine and informing my fellow students!

In these last two years, I have been putting effort in getting more out of a student's life, not only by joining the activity committee

f you consider how long I have been connected to the Faculty of Electrical Engineering, first for study, then for work, it is a wonder I haven't been a member of the Connecthor (or one of its predecessors) much earlier. But finally it has come to pass.

After my studies I first did research for a couple of years, but in the 1980s wind energy was not a thriving industry as it is now, on the contrary. After the decline of wind energy activities in the Netherlands in the 1990s. I first obtained a PhD based on my research, next to being a part-time student counselor and starting a family. As you may have guessed, combining all this didn't result in a speedy doctorate. My oldest son was 2 months old when I started writing. My youngest son is 6 years younger, and he was half a year old at my thesis defense - where he drank his first beer, thanks to Rob Kerkenaar. To be complete: in between there is a daughter. She picked up my fascination

Furthermore, I am in the promotion team of Electrical Engineering, which allows me to spread the word about Electrical Engineering and meet the new students of Electrical Engineering.

Connecthor I hope to contribute to the magazine by writing interesting content and maintaining the high quality of the articles. I am looking forward to being part of the Connecthor editorial team.

Until the next edition.

Margot 🔳

of Thor, but also by joining the department council to improve the quality of the education. Besides putting in effort in the quality for the current students, I also see value in giving future students the best possible advice for entering either our department or some other by helping at the information days and experience days.

I am looking forward to be working on the Connecthor together with the rest and making this the best magazine on the whole campus. See you soon! 🔳



for electricity best. All three were fascinated with buttons, but she was the only one who succeeded to create damage: she found the tiny 220V/110V switch on the computer I wrote my thesis on.

Shortly after obtaining my PhD, I became a member of the city council of Eindhoven, still in combination with being a part-time student counselor. In 2010, I ended my political career and became a full time employee of the faculty, first combining student counseling with educational policy, and currently involved in research policy.

What my contribution to the Connecthor will consist of, is still an open question. 'Emergent', if you prefer. If you have any inclination to influence this process, please feel free to do SO.

Jan Vleeshouwers 🔳



Prof. dr. ing. A.J.M. (Guus) Pemen

On February 1, 2017, Guus Pemen, of the Electrical Energy Systems group, was appointed professor. Congratulations!



loanne Oh - PhD cum laude

TU/e researcher Joanne Oh (ECO) received her PhD degree on her research on a wireless network based on harmless infrared ravs, with the 'cum laude' distinction on March 9, 2017. More about this research in this Connecthor magazine, written by Ton Koonen.

Goodbye Harrie Kuijpers

Harrie started his career at TU/e on May 1, 1976 as an electronic engineer at CTD. Eleven years later, in September 1987, he made the move to the department of Electrical Engineering.

After working for many years at Electrical Engineering (SPS), he was offered a farewell reception on March 8, 2017. His official leave date is April 15, 2017. We wish Harrie and his family all the best in the future.



Inauguration of "Leap into the deep"

n March 30, 2017 the 7.20 meter high and 6 meter wide sculpture "Leap into the deep", designed by Tijs Rooijakkers, was officially inaugurated. Applied Physics dean Gerrit Kroesen opened the event, followed by Tijs zip lining down from the Flux building towards the sculpture.

Tijs Rooijakkers explained what inspired him to create "Leap into the deep" and how the creation process took place.

After the inauguration, the crowd was invited into the Flux building to see the, for the occasion, cleaned Van Marum machine and to see the new bought art on the wall on floor one.

Joep Huiskamp, member of the TU/e art At the end of his speech, visitors were invited committee, talked about Martinus van for a drink in Het Walhalla. Marum, about his invention "the electrostatic generator" and about the art on the wall.



NEWS&DEPARTMENT



Goodbye-/hello gathering for Femke Verheggen, Wilma van Eck, Ellen van Mierden and Paul Hulsen

Femke is leaving EE, Wilma is leaving EE and starting at Applied Physics, Ellen and Paul have started at EE. We wish them all ots of success in their new positions.



Goodbye Suzanne

For 5 years, from the June 2012 issue up to and including the June 2017 issue, Suzanne Kuijlaars has been a valued member of the Connecthor team. Suzanne has decided to step down from the board. We thank her for all the hard work and dedication during this period of time.



Bv: Pauline Hoen

DEPARTMENT

Whose desk is this?

s Albert Einstein asked: "If a cluttered desk is a sign of a cluttered mind, of what, then, is an empty desk a sign?" My desk is usually occupied with piles of papers and piles of to-do lists. Periodically I just pick up those piles, and transfer them to their final resting place: the big waste-paper basket in the sky. However, since being invited to write this article I've cheated and kept my desk cleaner and emptier than usual. Now the photo's been taken, it'll probably quickly revert to its natural state.



Goodbye

Look at page 38 for the answer.

Although being from Brabant I didn't study in Eindhoven, or indeed the Netherlands. Instead, on a foggy afternoon in 1984 I took the train and ferry to Britain to study at university. This was a great cultural experience, before the Internet existed, and before the British knew about coffee. I spent the following nine years in Wales, England, and Scotland, leading to a doctorate in computer science on formal verification of digital circuits.

After some wanderings I returned to the Netherlands in 1995, to work for the Philips Natlab and NXP Research for fourteen years. In 2010 I fully moved to academia as full professor, in the Electronic Systems Group of professor Otten.

As might be expected from anyone working at the university, I like innovation. Innovative research is carried out in my CompSOC (predictable and composable multi-processor system on chip) team of bachelor and master students, PhD students, and staff. For me, working in a team is crucial to my enjoyment of work. I think we all have more fun, and are also more productive, when working together towards a shared long-term goal, working with a common platform and tools.

Innovation also takes place in teaching. To cope with growing student numbers in the EE/AU bachelor I have automated the examination and grading of my courses using Oncourse. To eliminate the substantial fraud that occurs during automated examinations on student computers (BYOD: Bring Your Own Device, not to be confused with Bring Your Own Drink) Martijn Koedam and I developed and deployed STEP (the Secure Test Environment Protocol). In essence, students boot their computer off a USB stick that restricts access to only the exam. This method is being adopted by the TU/e as a whole.

The TU/e is rightly known for its excellent collaboration with industry in the Eindhoven region and beyond. Having spent years in industry I think it is important to spot trends and (future) problems in industry and society. Following this, we develop concepts and principles addressing those problems, which must then be proven to a sufficient degree, before being (hopefully) taken up by industry. Recently I joined Topic Products, a company in Best, as part-time system architect to ensure that my link with the "real world" remains sufficiently strong.

By: Femke Verheggen

Dear colleagues,

As Thursday 13 April will be my last working day in Flux, the moment of goodbye is rapidly approaching. It forces me to look back on more than twelve years at the department of Electrical Engineering. When I started the department was a lot smaller, and it has grown to more than 400 people over the years. I have had the privilege to work for four different faculty boards at two different locations. I was present during many highlights but also during difficult moments, when we lost colleagues. For many years I was part of the Connecthor editorial board and I enjoyed working together with a team of students and employees to make this beautiful magazine.

And of course there are a number of people I would like to thank. First of all, the HR colleagues, who always supported me and became more than colleagues! And of course I would like to thank the board the department of Electrical Engineering. But most of all I really enjoyed working with all of you! These are the memories that I will take with me. Thank you for all the support, insights, and help you have provided me over the past twelve years.

Thanks again for everything and I hope to see you somewhere at TU/e.

Sincerely,

Femke



WIE Pub lecture

In the many years that I can call myself a student I have participated in a lot of excursions, lunch lectures and other similar events. During these activities a delegation of a company came to us to tell us about the company and what you can do with your engineering degree at that particular company. The emphasis here is on the company itself instead of the experiences of the engineer. I thought that the latter can be interesting and inspiring as well, hence I helped in organizing the WIE pub lecture.

give students some examples of career paths of alumni of our own department. What are their experiences so far? What choices have they made already during their study and how did they end up at the place they are working at this moment? During the pub lecture these questions were answered during four different presentations.

The overall idea for this pub lecture was to at MsM (NXP) and a graduation project at EM (Holst Centre), was very diverse, but the key in her choices was to choose for the most challenging option. She encouraged us to do the same: choose actively for challenging options within our own career.



The first presentation was given by Valérie Tjin-A-Djie and Iris Huijben, two students who joined Bluejay Eindhoven this year to work on an autonomous domestic drone. As electrical and software architect they are working on the electronics and the navigation of the drone. During their presentation they told us about the challenges they face. They learn to deal with expectations from companies, how to communicate within such a multi-disciplinary team, and how to deal with uncertainties. During courses you know that the assignment is feasible which is not necessarily the case at Bluejay. So, according to Valérie and Iris, being part of a student team is a valuable experience during their study.

The next presenter was Lulu Chan. She has followed the Automotive Leadership Trainee Program at NXP and now works at System Innovations. During her presentation, Lulu walked along the road of choices she has made until now. This road, starting at her bachelor project at ES, towards an internship

After the break Bianca Slaats took over. After the introduction where she shortly commented on her career path so far, she told us more about a project she is working on at Océ. She started with a simple explanation about how an inkjet printer works. Then she explained in more detail her specific task, which was to make sure that the image looks good by using smart solutions in image

The last presentation was given by Lindsey Vlaar, who after an active student life (e.g. board year, festival organization, committees, think tank Bachelor College) ended

processing.



ASSOCIATION

By: Marcella Gunther





up as Design Engineer at ASML since June 2016. So far she has learned several lessons which she shared with us. For instance you first need to gain recognition, so step forward and show what you can do. We should not be afraid of stupid mistakes, and we should not get confused when things are not what you expected. It was very interesting to listen to her experiences.

After the four presentations there was the opportunity to ask questions to all presenters and in the end we all went home with some



new life lessons. In my opinion it was very interesting to hear the different stories of the alumni and students, especially because they all have experienced the same things that we as students are experiencing now. Despite the small public the lecture was a success and I hope that the concept of inviting alumni to talk about their career path and choices will be used in future pub lectures as well.

ASSOCIATION

'Master association' Eir

For years, Thor already has two large master associations (in Dutch: 'disputen'): ODIN and Waldur. ODIN is mainly specialized in telecommunications, and Waldur operates in close collaboration with both the Electrical Energy Systems group and the Electromechanics and Power Electronics group of the department. In this article I am going to introduce Eir to you, a potential new master association of Thor. As Eir we want to focus ourselves mainly on Care & Cure related subjects, which nowadays is a growing subject in the curriculum of Electrical Engineering. At the time of writing we already organized two activities as Eir, which were both a great success!

🦰 ome time ago, the two master associations of Thor, ODIN and Waldur, had some troubles finding a new board. Because these associations had guite a network of benefactors and companies, it was a waste to just let them guit. So at this time there was an idea to set up one main master association for all students, whereas ODIN and Waldur were untill then mainly specialized in the telecommunication and the power electronics respectively. As a master student who was interested in the Care & Cure direction, this was an opportunity for me to also get this area of expertise involved and to organize electro-medical related activities. But luckily for ODIN and Waldur they found some new interested students to lead the master associations, and they lived happily ever after as if nothing has happened.

However, this shattered my dream a bit of getting more students interested in the Care & Cure direction. But then I thought: "Why not starting a new master association?" Then



that explains the name. For now we are just a committee of Thor, but when there is enough interest, we hope to become a master association. And with a bit of luck, we will grow as large and wise as ODIN and Waldur.

interesting lecture about neuroplasticity in clinical practice. Here we saw some examples of children suffering from a physical disability due to severe brain damage, where some of the disability was recovered due to the fact that healthy brain cells took over the task of

"Why not starting a new master association?"

I found Daan and Niels who had the same thoughts, and together we founded Eir. In the Norse mythology, Eir is a goddess and/or Valkyrie, associated with the medical skill, so



damaged brain cells. One example was a baby Since our foundation we have been pretty whose right hemisphere was totally damaged, busy. Our first activity was an introduction drink in which we presented ourselves so therefore it could not move the left part to interested students and for us to get an of its body. But in a few months' time it was idea of the interest in Eir. The presentation was basically the previous two paragraphs





already capable of lifting the arm slightly and after a year, the arm and leg could be moved again. However, it was only possible to mimic movements of the right part of the body, but still an impressive improvement.

This session continued with lectures about the memory on neuronal level and whether DCD (Developmental Coordination Disorder) was a development disorder or a learning disorder. Concluding there were some talks about dyslexia and dyscalculia, and the fact that genetics and the environment have more influence on these disorders than expected. Around 12.30 it was time for lunch, which was organized at Heeze castle. Here some delicious dishes were prepared for us, which we could eat in the lovely sun while enjoying the nice scenery of the castle.

Two hours later we were back at Kempenhaeghe for the afternoon session about 'clinical demand versus technological offer'. As few technicians amongst a lot of

terminology.

clinicians at this congress, this was a very Phew, a job interview

ots of us don't yet think about job interviews too much, especially in the bachelor part of our studies, but Brunel came by to show us that it's not too early to already start preparing. Two employees came over to talk with us about the job interview process, gave us very useful tips and they told us about how they conduct interviews. Especially these stories from 'the other side of the table' were very interesting and could prove to be very useful.

The two lecturers arrived a bit late and it took them 15 minutes and some of our assistance to get the presentation set up. This was a

good introduction to the most important aspect of a job interview: the preparation. The interview doesn't start the moment you sit down at the table in the office, rather it starts several days earlier. You have to do research on who you'll be talking to, what the company does, why you would like to work for the company, what to wear (you can just ask this when making the appointment, apparently) and what salary you think is appropriate. Also having representative social media accounts helps, since you will definitely be searched. Being prepared means a huge advantage for you and thus better chances of leaving behind a good impression.

ASSOCIATION

interesting topic. Also the chairs of this session were two professors of our own department, Johan Arends and Rob Mestrom. Here we started with a lecture about the differences between technicians and clinicians. It was fun to see that these differences are not only about knowledge, but also about language and approaches to solve problems. Whereas technicians make models and simplify everything, it is necessary for clinicians to have a lot of specific knowledge and to be able to tackle patient specific problems. The main point is that we should be aware of these differences and that it is worth to invest in each other's

After that, there was a talk about what technology was needed for epilepsy surgery and where there were improvements to make. The session ended with a talk about optogenetics/ chemogenetics, which could in the future be a treatment of epilepsy with the use of light or receptor-specific drugs, and a talk about

seizure detection and SUDEP prevention. After that, some stayed at Kempenhaeghe for a concluding drink, but the majority had digested enough information for the day and went back to the train station. Looking back it was really a nice and interesting day, and I am sure that we will attend the congress next vear as well

With this we look back at a few nice first activities of Eir. There are already some interesting activities planned for the fourth quartile, namely a group binding game of LasEirQuest and a lunch lecture from Philips Healthcare. We are also busy looking for a new board that can lead Eir as Niels is going on an internship abroad and I will be graduating in May. For those who are intrigued by all of this and want to know more about us, more information can be found at: https://ma-eir.nl, or just send an e-mail with your questions to board@ma-eir.nl.





By: Tom van Nunen

The presentation was accompanied with videos about do's and don'ts, some of which were guite obvious, but others of which we would have never thought about. The most difficult part of the training - at least for most of us - was to think about and write down three good aspects of yourself, as in, aspects that could be of interest for someone who might hire you. Some didn't like talking about themselves, because it was thought to be selfish to talk about oneself in such a way, whilst others simply couldn't come up with three aspects. All in all I really enjoyed the training, it will certainly prove to be very useful. 🔳

TECHNOLOGY

Robust optimization for oil recovery

By: Mohsin Siraj

Oil and natural gas play substantial roles in countless ways in our everyday life. They are like oxygen to our transportation system, heating our homes, cooking our food and help in generating electric power. By-products from oil refining are also the major building blocks of plastic products, cosmetics, fertilizers, asphalt etc. Though interest in alternative energy sources such as solar, nuclear, wind etc. is increasing at a rapid pace, the applicability of these sources is limited due to the cost and the basic infrastructure required to implement them. Especially the developing countries, which constitute a large part of our globe, still lack the necessary infrastructure to utilize these sources in an efficient way. Hence oil and natural gas remain instrumental sources of energy.

Oil production from oil reservoirs

The production (extraction) of oil from an oil reservoir has a life cycle of a number of decades and passes through different phases. In the primary production phase, oil is produced naturally due the high pressure in the reservoir. The pressure and hence the production rate drops with time and unfortunately only 5% to 15% of the total amount of oil can be extracted (recovered) in this manner. In the secondary phase, in order to maintain a desired level of oil production, the application of an external force is required. Usually fluids such as water are injected to force oil towards production wells. With this secondary phase of production, about 20% to 70% oil is recovered. To further improve recovery, the properties of the fluids (oil, gas or water) are changed e.g., by injecting steam or surfactants. This is classified as the tertiary or enhanced oil recovery (EOR) phase of production.

Water-flooding is one of the most common secondary recovery methods. In this recovery mechanism, water is injected to maintain reservoir pressure to displace oil towards the producing wells. This research focuses on

the economic optimization of this recovery mechanism. The water-flooding process is schematically depicted in Fig. 1.

The reservoir exhibits a very heterogeneous nature, which means that the properties of the reservoir, such as permeability, which is analogous to conductance in electrical circuits and determines how easy it is for a fluid to flow, varies along the reservoir. These heterogeneities directly affect the flow of the oil-water front and a production well can start producing water, known as water breakthrough, instead of oil as shown in Fig. 1. Water breakthrough is highly undesirable as oil is still left in the reservoir and it can no longer be extracted. To avoid such situation a 'smarter' decision strategy of injecting water in the reservoir is required.

A model-based optimization approach to oil reservoirs

Since more than a decade, the serious need for rationalizing the decisions involved in oil production and driving them with available knowledge in a more systematic way have been among the prime research questions in the petroleum engineering literature. The concepts from the theory of systems and control such as dynamic optimization,

tion of reservoir models can be very beneficial in increasing the production of oil from oil reservoirs. With the technological developments, especially with the introduction of 'smart wells', the opportunities for the use of model-based optimization have increased. The basic idea behind model-based optimization is to devise optimal decisions, e.g., water injection strategy, by making use of

parameter estimation and complexity reduc-

available knowledge, e.g., the dynamic model that represents how fluids flow in the reservoir, with practical operational constraints and an economic objective. Model-based optimization is equipped with useful tools to cope with uncertainties and handle complex models with nonlinearities. The economic objective quantifies the economic value of oil reservoir over its production life cycle. A typical synthetic reservoir model is shown in

In the oil industry, the use of model-based optimization with the available sensors and control valves is often referred to as smart fields, intelligent fields, real-time reservoir management, or closed-loop reservoir management. Model-based dynamic optimization of the water-flooding process has shown significant scope for improvement

Fig. 2.





iqure 2. A reservoir model with low and high permeability regions. The vertical pars refer to injection and production

of the economic life-cycle performance of oil fields compared to a more conventional reactive strategy. In these optimization problems a financial measure, i.e., Net Present Value (NPV), is maximized. NPV is a net value of the revenue generated by oil production subtracted from the cost involved in water injection. It is a cumulative cash flow over the life-cycle of oil reservoir which also considers the value degradation over time via a discount factor. The optimization problem of the waterflooding process is highly complex, non-linear and non-convex optimization problem. One of the key challenges in this optimization is the uncertainty arising from the modelling process of water flooding and from strongly varying economic conditions. As a result, the potential advantages of such optimization are not fully realized and the risk of losing the expected economic objective is very high.

Geological uncertainty

The dynamic reservoir model is the most important ingredient of model-based optimization. Reservoir models provide a mathematical representation of the dynamic behaviour of the reservoir, i.e., how fluids flow through the reservoir as a result of a depletion (e.g., water injection) strategy. These models suffer from high levels of uncertainty about the model structure and the model parameters. Geological uncertainty arises mainly due to the lack of knowledge of subsurface geology that defines the reservoir. The quality and the uncertainty of reservoir models make the performance of the optimization strategy less reliable.

Economic uncertainty

Model-based optimization aims at maximizing some economic measure to improve the production of oil from oil reservoirs. Economic variables, such as oil price, interest rate, etc., which give an economic value to oil reserves, fluctuate with time and cannot be predicted correctly. Unlike geological uncertainty, economic uncertainty grows with time and has a dynamic effect. With the long life cycle of reservoirs, using a fixed and certain value of these variables results in an unreliable optimal strategy.

Decision making (optimization) under uncertainty

The objective of the research is to develop novel robust optimization strategies to improve the performance of model-based decision making under both geological and economic uncertainty for the economic operation and production of oil from oil reservoirs. We have considered two distinct solution trajectories to achieve our research objective. The first set of approaches aims at mitigating the negative effect of uncertainty in an openloop situation. In the second solution direction, the main focus is to reduce uncertainty by using available information (production data in our case) in a closed-loop (adaptive) settina

Uncertainty is guantified with a scenariobased approach where model uncertainty is characterized by an ensemble of reservoir models, and economic uncertainty is represented by an ensemble of varying oil prices. The research objective leads to four principle themes or research sub-questions:

Theme 1. Handling uncertainties in balancing short-term and long-term objectives.

NPV is defined as a sum of cash flow over the life cycle of oil reservoirs. Due to the long life cycle, the optimization problem focuses on long-term gains, while short-term production is generally neglected. This typically results in low short-term gains compared to those resulting from a reactive strategy. Furthermore, due to the high levels of uncertainty in this model-based economic optimization the resulting optimal strategy is highly uncertain. Theme 1 of the research aims at devising optimal solutions to the model-based optimization problem that balance short-term and long-term gains and at the same time provide robustness to the predicted NPV under both economic and geological uncertainty. To this end, a multiobjective optimization framework is adopted. A robust objective, i.e., an average NPV over an ensemble of geological realizations, with a focus on long-term gains is chosen. The



TECHNOLOGY

secondary robust objective is the same, except with the focus on short-term gains. To improve robustness, a single mean-variance optimization approach is introduced which with the maximization of the average NPV also minimizes the variance of the NPV distribution. The reduction of variance corresponds to minimizing the effect of uncertainty on the achieved NPV.

Theme 2. Asymmetric risk measures for optimizing the probability distribution of economic performance of oil reservoirs.

Due the symmetric nature of variance, a mean-variance optimal solution equally penalizes both the worst-case and the bestcase NPV values. In a maximization problem, a decision maker is mainly concerned with the worst-case values. Therefore, concepts from the theory of risk which provides a systematic approach to handling uncertainty with well-defined risk and deviation measures, are used to provide an asymmetric shaping of the NPV distribution. It corresponds to improving the worst-case NPV values without heavily compromising the best-case values. Different asymmetric or downside risk and deviation measures such as worst-case optimization, Conditional Value-at-Risk (CVaR) and semivariance are considered with both geological and economic uncertainty.

Theme 3. A closed-loop/online (adaptive) robust approach to reduce geological uncertainty using residual analysis.

In this approach, we analyse how the available information (data) can be used to shrink the uncertainty space. A traditional way of quantifying uncertainty in robust waterflooding optimization is by considering an ensemble of uncertain model realizations. These models are generally not validated with data. Hence they may provide a (very) conservative description of uncertainty. A robust online closed-loop scheme is developed using the concept of residual analysis. The basic idea of residual analysis is to confront models in an ensemble with data such that models are invalidated if they do not sufficiently agree with the observed data. A deterministic metric, i.e., the Best-Fit Ratio (BFR), is used to define the invalidation test.

ITECHNOLOGY & ASSOCIATION

An adapted ensemble is formed with only those models that are not invalidated thus providing a less conservative description of uncertainty with a reduced number of models in an ensemble. The adapted ensemble is used for robust optimization in an online fashion. This online adaptive robust scheme with its steps, i.e., data collection, residual analysis and robust optimization with the adapted ensembles, can be repeated at each time step till the end of the production life of the reservoir.

Theme 4. Data-driven sparse estimation techniques to quantify inter-well connectivity in oil reservoirs.

In case of large-scale reservoirs with hundreds of injection and production wells, the complexity of model-based control and optimization is drastically increased. In a two-level time-separation approach, the lifecycle economic optimization and control are decomposed into two levels of a hierarchical structure. In this research theme, we focus on reducing the complexity of multivariable control problem. A data-driven estimation approach is introduced to identify the

dominant control inputs which matter the most for control and to remove the nondominant ones. We use system identification theory with sparse estimation techniques to quantify the interactions between inputoutput pairs which also corresponds to finding

the inter-well connectivity in oil reservoirs. An input which does not affect any output is considered to be non-dominant and hence it can be removed from the control synthesis problem, thus reducing the complexity of the multivariable control problem.



Bosch excursion

n the Bosch Experience Day in Weert, we learned about the different branches within Bosch. Most people know the company from the power tools like dremels and drills, but we found out more about the diversity within Bosch. Their products range from high-end camera security systems that can track movement on camera, to powertrains used in cars all over the world. At the Bosch fair, representatives of each different branch discussed their expertise. During the tour of the facility, we learned all about packaging techniques.

At the site, they produce Vertical Forming, Filling and Sealing bags. These machines produce the bags you might see wrapped around your cornflakes, chips, or salted peanuts. Different from regular candy bars, which are packed horizontally, a whole other story. The bags are delivered on a roll of thin film, which is fed into the machine. On a shoulder-like structure, the film is formed around the forming tube, through which the to-be bagged product falls. The sides are melted together to form a cylinder. At the bottom of the tube, a set of horizontal sealers closes off the last bags' top and this bags'

bottom. The product falls into the bag, after which the top of the bag is sealed and ready to be boxed by another Bosch machine. The result is the most standard bag the machine can produce. Next to the standard pillow bag, the machine can also produce standing bags, block bottom bags, doy bags and all the rest.

By: Gijs Neerhof

Research on new techniques is done in-house, and during the afternoon case study, we learned that a single M&M could stall the machine for over half an hour when it gets in between the sealers. Solving these issues timely, for example by using a different type funnel, can stop the clogging of M&Ms and give consistent batch sizes.

Overall, the day was a success. We learned that, while dremels are fun to work with, Bosch also houses other branches with several disciplines working together on quality products.



Remarkable examination work

Examination work is a source of unused potential, insights and humor, currently only available to the privileged staff reviewing the work. This series shares some of the most remarkable work, with permission of the authors of the work.

or the bachelor course in Power Engineering, Guus Pemen allows students to bring one A4-size piece of paper with notes. The idea is to stimulate students to make a thorough summary, but some summaries are more summary than others. Student Ector¹ created the summary shown below.

Actually, the summary lists every single topic covered by the course. The print is so small, about 2.5pt, that we suspect Ector of using magnifying contact lenses during the examination. If we would use this size for the Connector mean remaining the second seco

He was a little disappointed in the printer he used, because it left out some of the text and figures to the left and at the bottom. And, after having printed the page, he was still not completely sure about a couple of simple equations, so he wrote them below the figures. He should have checked his summary, though, because the equations are in it. Somewhere. We guess.

2. "You would never again read anything in it."

DEPARTMENTI

By:Jan Vleeshouwers



^{1.} Not his real name

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Shell: a world of opportunities

Taking on the energy challenge

You may not think it when you switch on a television set, but when you look at the big picture, human society is improving itself on pretty much all fronts. Collectively, over the past hundred and fifty years or so we've seen a tremendous increase in wealth, life span and personal freedom while at the same time poverty, disease, famine and war have decreased significantly. That does not mean everyone is better off everywhere, but on average a human's life has become significantly longer as well as a whole lot more pleasant. Advances in technology, engineering, medicine and production efficiency are at the base of that progress.

Many factors have helped making those advances possible, but an increased availability of energy has certainly been one of the enablers for it. Energy is the ability to do work, to move people or things from A to B, and to change the world around us. For more than a century, Shell has been a pioneer in the energy industry and helped provide societies around the world with the fuels and energy they require.

According to the latest estimates global population will grow from 7 to over 9 billion people by 2050. Due to improved standards of living the global demand for energy is expected to grow even faster, doubling from 2000 to 2050. At the same time emissions of CO₂ need to be reduced significantly to limit the impact of By: Jasper Stolte



climate change. Human ingenuity, innovation and technology hold the key to responsibly unlocking the energy needed today and in the future.

A world of opportunities

An energy company like Shell is not what most neering background in disciplines such as

electrical engineers think of first when they're looking for a job after their studies. From my discussions with students at events like the Wervingsdagen I've noticed that many are not aware that Shell employs people with an electrical engineering background. Actually, there are great opportunities to work in a company like Shell for people with an electrical engiPower Engineering, Process Automation and Control Systems, but there are also more general positions in the area of Information Technology or R&D.

After completing my own studies at the TU/e my starting position was Process Control Technologist, taking care of the control systems for a large chemical plant called a steam cracker in Moerdijk. The beauty of control systems is that you're working with many different disciplines and groups. Together with operators and process technologists you come up with a strategy for how to best operate a plant. You're making process models based on data that you generated from plant tests, and using those models, you can build controllers which optimise the process. When you have implemented a new controller you can really see how much energy you saved and/or how you improved control of product quality. My main task at the steam cracker was to do a major upgrade of the model based controllers.

One of the best things about starting at Shell is that you can immediately start making a difference. From day one you get a real job with your own responsibilities. The atmosphere is great and everyone is willing to help you. Personal development of its employees is important to Shell and each employee has their own development plan. After all, fully developing your potential is in the interest of the company as well as the employee. As a 'graduate' you can benefit from a whole range of training and development courses to prepare you for a succesful career. Shell is a large company with big inspiring projects and plenty of opportunites to broaden (or deepen) your personal skill set.

After two years of working on the steam cracker I moved to another chemical plant at the same Moerdijk site. This plant is using some of the steam cracker products (propylene and benzene) as feed to produce styrene and propylene oxide, which are both important base chemicals for the production of all kinds of plastics, foams, and other materials. While working at that plant I got involved in pilot testing for our new process control software platform. That new platform has been developed within Shell and safely testing and rolling out this new software package is a good challenge for me.

One year ago I moved from the Moerdijk site to the global Projects & Technology department which is headquartered in Rijswijk. From there I worked on complex control systems and continued the rollout of the

new software package throughout our region, with most of my projects running in the Netherlands, Germany and Qatar. Since Shell is a true multinational with activities in many countries, there is always an interesting challenge somewhere!

A time of transition

The 21st century is going to be one of great transformation in the energy sector. The world will move towards a lower carbon energy system and Shell wants to play a leading role in that transition. To that end we are working on things like carbon capture and storage, development of biofuels, building a network of hydrogen fuelling stations and wind energy projects. However, renewable sources alone will not be sufficient to supply all the energy that societies need.

The industrial sector emits as much CO₂ as the power sector and it cannot simply switch to 100% electrical inputs. The basic chemical processes of steel and cement manufacture





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mean they will inevitably emit CO2. Today, there are no easy replacements for hydrocarbons that can provide the intensity of heat required for these and other industrial purposes. The weight and capacity limits of batteries mean there is no immediate zerocarbon solution for air travel, shipping or heavy freight. Thus, fossil fuels will continue to play a role in the energy system for decades to come.

Supplying the world with the energy it needs while at the same time transitioning to a lower carbon footprint is a big challenge and Shell will need talented people to make that a reality. After your studies in electrical engineering you are well placed to join a company like Shell and take on the energy challenge. Interested? Go to www.shell.com/careers for more information on Shell and the Graduate Programme.

ITECHNOLOGY

InMotion

By: Bram Hooimeijer

InMotion is currently working on the fastest electric formula racer in the world. Highly ambitious goals. The Connecthor went for a visit with team manager Bram Hooimeijer (Electrical Engineering) to see how they are doing.

irst, a small introduction: InMotion was founded in 2012 with the goal of competing in the 24 hours endurance race at Le Mans. The team aims to participate in the Garage 56 class, which was introduced to facilitate innovative projects. In this class, one car is allowed to race among the others but is free from any technical restrictions except for safety regulations. InMotion is heading for France with a very special car, the IM01, which combines individual four wheel electric drive with an active suspension and aerodynamics management. Both concepts that have been banned from racing. Their goal is to use cutting edge technology and complex control systems to build the fastest race car possible. However, first InMotion is building an electric formula car, the IM/e. They use this machine to prove concept, test technology and strengthen partner- and friendships to stand by during their "Road to Le Mans".

So what has happened since we have spoken each other in September?

"Well, in August we had anticipated to shake down our car at circuit Zandvoort during the Masters weekend. Although we have not been able to drive the IM/e there, we had a lot of publicity. Even now, seven months later, people refer to having seen us that weekend" says Bram. "In the following weeks we have been working on a redesign of the electronics. The IM/e contains multiple Board Computers, a digital steering wheel, inverters, Battery Management System, batteries, a power distribution system, and many sensors,



The IM/e after its first demonstration, during our partner event in January. Nick Catsburg drove the first meters, leaving for the 24h of Daytona only a week later. Photograph taken by: Gerlach Delissen

all of which communicate via a CAN-bus. Integrating all these components such that the entire system is stable and reliable has been a difficult task."

"During our partner event in January we surprised our guests with a demonstration. From this moment on we have used all our time to test as much as possible while simultaneously improving the car." After spending quite some time at the test bank of Fontys, the team headed for a track test in Lelystad. "We need to drive until something breaks down"



says Bram. Luckily for them all went well up to speeds of 120 km/h. "This was beyond expectations for a very first test!"

What challenge do you face in building such a car?

"Building an electric race car obviously contains some electrical challenges. We are dealing with about 800V and 400A in a very limited space. That means that all of our communications lines are running near to the high voltage modules" answers Bram. After the last track test InMotion experienced some problems with electromagnetic interference. To solve this the team occupied the AES Lab in Gemini for a whole week. Bram: "It was great to be able to extensively test and iterate our system on the test bank, we want to especially thank René, Lex and Ramiro for their involvement and valuable contribution to our project".

One week later, during the public day of the Automotive Week (March 26th), the team was able to test on the highway between Helmond and Eindhoven, which was closed due to the E-Parade later that day. InMotion was able to use the road for a full two hours in advance



Rinus van Kalmthout, driving the USF2000 as KNAF talent-first driver, d the A270 in front of the crowd.

of the event. During the event itself the team demonstrated the IM/e in front of the Automotive Campus for a large and enthusiastic crowd. Bram: "We had a wonderful day, the car remained stable at high speeds and our photographer made some great shots".

So what is next guys?

"In April we are heading for Zandvoort. When this article rolls off the press, we hope to have extensively tested and optimized the cars vehicle dynamics". The setup of the IM/e is the most important task the team is now facing. At higher speeds the aerodynamics start to work and G-forces in corners demand precise setup of the suspension. Once the car is optimized for racing the team is ready to break the electric lap record at circuit Zandvoort.

When the team has the record at Zandvoort they will keep on testing at other tracks like Zolder, TT Assen, and SPA Francorchamps. "The major next challenge is the electric record at the Nürburgring Nordschleife, which is set by an incredibly fast car: the NEO Next EV. The length of the track is just over 20 km, which challenges our battery pack. Due to the limited dimensions of the car we will need to improve the capacity per volume of our batteries" says Bram. In order to get the car up to the record of 7.05, InMotion will implement various systems as traction control and torque vectoring.

The goal is to participate in the 24 hours endurance race of Le Mans, how are you preparing for that? Bram: "The formula car we are currently building allows us to learn from the challenges we are facing, thus allowing us to solve them quicker during the development of the IM01, the Le Mans Racer. Secondly, we are gaining publicity and partners that support our journey". Next year InMotion is starting with the realisation of the IM01. The team will simultaneously race at circuits in order to test various systems for the Le Mans car, and implement these in the design of the IM01. A lot of research has been done already, Bram explains, but implementing and optimizing the systems poses a different challenge all together.

The IM01 is a big step up compared to the current formula car. It will have four motors instead of two and hence doubles the power



TECHNOLOGY

from 550 to 1100 hp. Moreover, it will have to drive over 24 hours, spanning a distance comparable to the length of a complete F1 season. In total the car will cost a lot more than the current project, also because a complete team is needed to perform at the 24 hours race. InMotion is looking for a big financial partner to support all of this.

Ambitious goals! Will you still be involved all the way down to Le Mans?

"Of course, I will stay involved with the project. I cannot wait to see the IM/e beat down the Nürburgring" says Bram, "but I have to get back studying as well next year. We are looking for a team for next year, with students from both the TU/e, as well as from Fontys" explains Bram. InMotion is driven by a team of fulltime engineers, marketeers, and designers who often contribute to the project for a year.

"Students will have a tremendous opportunity to develop themselves. A year at InMotion exposes you to both technical and soft skills." Next year the team will have a conceptual design project running along a practical test case. "The crossover between the two is great, you can pack the trailer any weekend and go visit a track" says Bram. "I really believe that a student team is an unforgettable experience for anybody, as long as you dare to pick up the challenge".

Do you dare? Then please have a look at <u>www.</u> <u>inmotion.tue.nl</u> or contact us via <u>HR@inmo-</u> <u>tion.tue.nl</u>.

Like InMotion on Facebook and stay up to date of the latest developments: <u>www.facebook.com/TUeInMotion</u>.

























shop 6. ACCI pubquiz 7&8. Masquerade party

18







1. ACCI Valentines drink 2&3. Ivaldi Open House Day 4&5. Volundr Internet of Things work-

9&10. Thordictee 11&12 Carnavals party 13&14. Analog LAN party 15&16. Visit Hertog Jan Brewery 17. Ivaldi neon party 18. Make Thor great again party

TECHNOLOGY

Intimate technology

here is a cluster of technologies in nanoscale physics, bio-engineering, information & communication, and human cognition which increasingly converges. This cluster has been acronymed NBIC, after the first letters of their constituents' topics. Google around a little and you will find a lot of buzz, in particular about what these technologies might bring humanity in the future.

As you probably noticed, Electrical Engineering plays a substantial role in all four areas, so whatever this technological convergence may bring, we are in the middle of it. At the EE-2050 Symposium in January, there were many references to it: current day possibilities of course raise expectations for the future. But rather than trying to predict the future, I'd rather put some effort in exploring this topic and to give it more structure. This article is the first step in – I hope – a process of which I'll try to keep you updated, and of course you are invited to take part.

The title of this article refers to a Dutch essay ¹ by Rinie van Est, who works at the Rathenau Institute and (one day a week) at TU/e. You can download it from the Rathenau website.

The essay's primary observation is that technology, especially NBIC-technology, is getting closer to our body and minds, in more ways than one. Of course there is a physical side to it, of technology on and under our skin. But secondly, there is more and more technology involved in the interaction between humans. And finally, technology is looking and behaving more and more like humans.

We respond to these developments in a paradoxical way. On the one hand, people embrace these new technologies whole-heartedly. On the other hand, there is plain fear: fear of losing privacy, freedom and individuality. Van Est finds middle ground by stating that we should use new technology in a human way. There should not be a halt to technological development, but individual autonomy and freedom are too important to give up. There will probably be areas of life which should be void of machines. Government is still largely

unaware of the pervasive nature of these technical developments, and is urgently requested to take up this discussion seriously.

Do you agree? I largely do, and my preoccupation with structure leads me towards other questions. The NBIC-development is hardly new. Humans have been applying technology on their bodies for as long as we know they exist, and history shows a continuous struggle between proponents and opponents of technical novelties, sometimes leading to large and completely unforeseen changes in society. Where does this relentless drive originate from? Don't tell me it is economy, because humans were technical long before they were economical.

A related, more philosophical question is this: if technical behavior is so deeply human, where does the fear come from? Or perhaps related: what exactly does technology do to human individuality, freedom and autonomy?

And to conclude for now: what is our involvement in all this? Van Est expects engineers will not stop their work in advancing technology. But then? Should we engage in the related economic issues and be satisfied with that? Or should we get into politics, as suggested in the panel of the EE-2050 Symposium?



1. Est, R. van, with assistance of V. Rerimassie, I. van Keulen & G. Dorren: Intimate technology: The battle for our body and behaviour. The Hague, Rathenau Instituut 2014. Original title: Intieme technologie: de slag om ons lichaam en gedrag. (translation K. Kaldenbach). https://www.rathenau.nl/en/publication/intimatetechnology-battly-our-body-and-behaviour.

Icons of EE: Edwin Howard Armstrong

I hile many people would associate the name Armstrong with space travel or cycling (Neil Armstrong and Lance Armstrong respectively), Edwin had nothing to do with both of these areas. Edwin was an American electrical engineer which is best known for his developments in radio communication. He invented a new way of radio communication which was less effected by electromagnetic interference than the amplitude modulation (AM) used back in the days. This invention is applied in some of today's communication systems and is better known as the FM radio.

Edwin was born on 18 December 1890 in New York City as the oldest son of John and Emily Armstrong. His father worked at the American branch of the Oxford university press and generated a modest income to the family, so Edwin grew up comfortably in the middle class. When he was 8 years old, Edwin was afflicted by the Sydenham's chorea, which is a neural disorder which expresses itself in physical tic under some conditions as stress and excitement. Already at this young age, Armstrong began to show interest in electrical devices.

After graduating from high school, Armstrong enrolled himself at the Columbia University in 1909 as an Electrical Engineering student. During his study, he really focused on the topics he liked, while not really caring about the rest of the topics. He saw progress as something which was more likely to be obtained by practical experimentations than from raw theory and calculations. Once, while doing some experiments, he even tricked an instructor he did not like into getting a pretty bad electrical shock. After his graduation in 1913, Armstrong served in the US army during World War I as a captain and a major.

One of Armstrong's first major accomplishments has to do with vacuum tubes. Vacuum tube technology was developed in 1906 by Lee de Forest and was so new that nobody really knew how these components actually worked. While doing experiments with these vacuum tubes, Edwin gained a lot of scientific insight in the working of these tubes. His first breakthrough study was about the use of positive feedback to gain a higher amplification. The results of this study were very good, while the amplification was 100 times greater than the original design he started with. The



concept of positive feedback got patented, and led to several legal proceedings between Armstrong and De Forest, which eventually led to Armstrong losing his patent in 1921.

These legal battles about the positive feedback (also called regeneration) have of course delivered Edwin a lot of trouble, but it also had a very positive side effect. While in these legal battles, Edwin accidentally encountered something what is known as super-regeneration. This super-regeneration would have an even bigger amplification than his original study of regular regeneration. Armstrong would however not hold on to this patent very long, because he sold it already in 1922 to RCA in return for 200,000 dollars and a lot of corporation shares.



TECHNOLOGY

By: Matthijs van Oort

In 1928 Armstrong began with his research on frequency modulation (FM). The concept of FM was not new at the time he started this research, but it was not seen as an improvement over the already proven AM technology. Edwin already had some insight in the research going on at RCA, while being a major shareholder. Research done by some RCA engineers proved that a FM shortwave link was less effected by electromagnetic interference than AM, but that's where the research ended. However, Armstrong started developing wide-band FM secretly in a basement laboratory. The results of this wide-band concept proved to have far better performance than the narrow-band FM. Because RCA had an agreement with Armstrong for the right of first refusal to his patents, Edwin presented the system first to RCA. However, RCA did not invest in FM, which was in their eyes too complex to implement in radio stations. Armstrong decided to finance the project with his own money (with some help of smaller companies) and present the system to the Federal communication commission in 1936. This was the beginning of a wide adoption of FM radio systems.

In his whole life, Edwin Howard Armstrong obtained (and lost) a lot of patents in the area of radio communication. For these inventions, Edwin got two awards: the IEEE medal of honor (1917) and the IEEE Edison medal (1924). He can be considered as a pioneer in FM technology and one of the greatest engineers in telecommunication.

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hese days, a small USB stick costing only €10 can hold up to 16 GB of data. In hospitals, a camera the size of a pill can be swallowed to survey a patient's intestines. Modern pacemakers, critical devices that control abnormal heart rhythms, are now less than a tenth the size of earlier ones. And in the oceans, tiny GPS transmitters track endangered turtles to help protect them.

While these devices are incredibly small, they represent a big milestone in technological progress. At the heart of each of these lifeenhancing innovations is a microchip – a tinv package of integrated circuitry that powers the performance of the device.

In a world in which major breakthroughs measure only a few nanometres in size, the constant quest is to produce chips that are smaller, faster, more effective and less expensive. One of the major high-tech players leading the quest is ASML, a manufacturer of lithography systems for producing computer chips.

Crucial step

ASML, located in Veldhoven in the Netherlands, supplies equipment to all the world's major chip manufacturers. These include Samsung, Intel and TSMC.



There are dozens of steps along the path to producing a chip. ASML helps manufacturers take just one of these steps, but it's a very crucial step: lithography. Lithography involves exposing and chemically etching the wafers used to 'print' a chip's components. The more accurate the lithography process is, the smaller the resultant microchip can be.

Using ASML's latest generation of machines, it's possible to print lines on chips that are only about 20 nm thick. To put this into perspective... that's like printing the contents of a 500-page novel onto a centimetre-long strand of human hair!

Opportunities to be part of progress

To continue leading the race to produce smaller, faster, cheaper chips, ASML is looking for people who always want to do better and never give up. People who love what they do - not because it's easy, but because it's hard. People who will help find the best idea, the best solution, the best way forward.

People pushing technology further

The driving force behind ASML's technological breakthroughs is its forward-thinking engineers. ASML's more than 16,000 employees are some of the most creative thinkers in the world of physics, mathematics, chemistry, mechatronics, optics and informatics. And because ASML invests over €1.0 billion



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Be part of progress

annually into Research & Development, these experts have all the resources at their disposal to push progress to the extreme. It's the only way ASML can maintain its edge - worldwide.

A place of learning

ASML is an ideal environment for professional growth and development. The company offers a fulfilling career, not just a job. ASML rewards employees competitively and provides coaching, training and personal career development. Flexibility, enthusiasm, ambition and customer focus are the foundation for a world of opportunity. To find your opportunity, visit www.workingatasml.com

Superconducting electromagnetics

Let me first introduce myself, my name is Bart de Bruyn. A bit more than three years ago, I had the opportunity to start a PhD project in the group of Electromechanics and Power Electronics, on the topic of superconducting linear motors. The goal of the project was to investigate whether superconductors can be used to make a motor which has a much higher force per volume ratio than conventional motors, and which is able to produce highly dynamical forces. These new kind of motors could be at the heart of the next generation of photolithographic machines.

lot of people's first thoughts, and maybe yours too, are that super-Conductors can carry high currents without any losses. This is partially true, but the complex physics of superconductors proved to make the design and modeling of a superconducting motor a challenge. In the following story, I will try to give some insight into the most interesting challenges I encountered.

Superconducting materials

Many different superconducting materials

exist. The first one to be discovered was

4.2 K. Onnes tried to make an electromagnet

out of the material, but found that the super-

are brittle ceramic materials. Long conductors can therefore only be produced by depositing a layer of the material of approximately 1 micrometer thick on a substrate. The resulting tapes are then enclosed by a copper layer for thermal and mechanical stability.

Properties of superconducting materials

Superconductivity is a quantum-mechanical effect which results in perfect conductivity as well as the expulsion of the magnetic field from the superconductor when it is cooled below its critical temperature. For the hightemperature superconductors, an additional effect for substantial applied magnetic fields is the 'trapping' of the magnetic flux in the superconductor, which allows a permanent magnet to be levitated above a superconductor, as shown in Figure 1.

mercury, in 1911 by Heike Kamerlingh Onnes (a Dutchman). The material becomes superconducting below its critical temperature of

conducting state was broken by applying a These new kind of motors could be at the heart of the next generation of photolithographic machines.

magnetic field to it. Many other superconducting materials have been found since then, all with critical temperatures below 30 K.

Finally in 1987 high-temperature superconductors were discovered, which are superconducting at temperatures above 77 K (-196 degrees Celsius), the boiling temperature of liquid nitrogen. These high temperature superconductors can withstand high magnetic fields, and are the focus point of my research into superconducting motors. High temperature superconductors (HTS)



TECHNOLOGY

Bv: Bart de Bruvn



77 K, a typical 4 mm wide, 0.1 mm thick superconducting tape has a critical current of 110 to 250 A.

Although for DC currents the resistivity of the superconducting tapes is near zero, losses occur in superconductors for AC currents or for applied AC magnetic fields. These losses should be removed by a cryocooler, which has

These effects were modeled and measured on a macroscopic scale by an equivalent resistivity of the superconducting material. This resistivity increases exponentially with the applied current, as shown in Figure 2.

The critical current is usually defined as the point where the voltage over the superconducting tape equals 1 microvolt per centimeter. Well below the critical current, the resistivity of the superconducting tapes is close to zero, and DC currents are conducted with virtually no losses. At a temperature of

a very low efficiency. Therefore, the accurate estimation of the AC losses is crucial. These losses depend on the superconducting material parameters, which are not constant.

The parameters of the superconducting tapes depend both on the operating temperature and the applied magnetic field. At a temperature of 4 Kelvin, the critical current of an HTS tape is approximately 10 times higher than that at 77 Kelvin. If a magnetic flux density of 1 Tesla is applied to the tape, the critical current decreases by about 70% at 77 K. ►



ITECHNOLOGY & DEPARTMENT

Additionally, this decrease depends also on the angle of the magnetic field relative to the tape. Because of this field-dependency, the maximum current that a coil wound of superconducting tapes can conduct is lower than the critical current of a separate section of the tape.

To be able to design a superconducting motor, models have been developed that can calculate the maximum coil currents and the losses in the coils resulting from applied currents and magnetic fields. To validate these models, the AC losses were measured.

Measurements on superconducting coils

Because of the high accelerations and deceleration in the superconducting linear motor the coil currents are non-sinusoidal. Since the methods used in literature mostly



considered only low-frequency or sinusoidal currents, a measurement system was developed to measure the AC losses resulting from these non-sinusoidal waveforms. During the measurements, superconducting coils that had been wound were submerged in liquid nitrogen, as shown in Figure 3.

Currents with a peak value up to 50 A are applied to the coils. During the measurements, a current density in the coil of 70 A/mm² is reached, while in conventional electric motors the copper coils operate at a current density of 5-10 A/mm².

Modeling of superconducting motors

To evaluate various designs of the superconducting motor, fast models for the calculation of AC losses and forces are required. The losses depend on the material parameters (which in turn depend on operating temperature), the motor geometry, the motion profile, and the currents applied to the coils. Finite element modeling was chosen since it is able to include all these details.

The properties of the superconducting materials and tapes make finite element modeling of superconducting coils challenging. First, the superconducting layer in the superconducting tape is only 1 micrometer thick, while the tape is several millimeters wide. This large aspect ratio makes standard generation of the

mesh elements of the finite element model problematic. Secondly, the highly nonlinear material properties, especially the highly nonlinear resistivity as function of current density, make the finite element models very slow, because in a time-dependent simulation very small time steps have to be taken for the models to converge. As a result, modeling of a full motor with many superconducting tapes will lead to very long calculation times (about 1 hour of calculation time per millisecond of simulated time). Therefore, a number of model reduction methods were implemented to drastically decrease the computation time. Using the finite element models, the losses measured in the experiments can be reproduced, as shown in Figure 4.

Continuation of the project

For the final half year of my research, a prototype motor of which the losses can be measured is in development. The measurements on this prototype will be the final validation of the implemented models. I can look back on a period where I learned a lot about electromechanics, and enjoyed the PhD life. The research on superconductivity will be continued in a next STW project, in which the EPE group will work together with three industrial partners and the University of Twente to develop a full-scale prototype motor.

Paris holds the key (to your heart)

A joint PhD programme between the Netherlands and France, where you get to spend half of the time in Eindhoven and half in Paris, sounds good? I'll be honest, the city of lights played a big role in my decision making. The charm, the history, the variety of possibilities for any kind of activity one could wish for - everything was in place to ensure my first encounter with this city remains memorable. And it truly was. It was a real disaster.

Alcoholic housemate, one hour of itinerary to work and an environment where no one spoke a word of English are only some of the things. The experience in the city of love rience, my mind was set to the best. French

hat could possibly go wrong in the above mentioned scenario? The main factor with a new experience is a mind-set. Whether it be watching a movie, travelling abroad, or even reading this article. We already have an idea of what we want to acquire from it. In the case of my Parisian expe-

I had to take off my pink glasses and face the reality.

became quite the opposite. As they say: there is a thin line between love and hate. I had to take off my pink glasses and face the reality.

for me being the most beautiful language, Paris the most beautiful city, and photonics the technology of the future. Therefore the chances of failure were fairly high. Once I have faced the opposite of my expectations I was ready to accept the reality.



I still consider French the most beautiful language, however, when you live in France and do not speak French, it becomes awfully hard. If you think people at work at least spoke English, you are far from the truth - very few of them speak very little English. And taking into



account they are in their own country, why is there a need to speak any other language? In comparison to the Netherlands, where even

pretty efficient when they are working, probably to be able to enjoy even more the breaks afterwards.

The biggest change for me after the Netherlands was the concept of a lunch break. Yes, the concept, as it is much more than a simple break. It is the time when you enjoy the good food, when you get to talk to many colleagues, get into discussions about any off-work topic and maybe even enjoy a nice glass of wine (though rarely).

All in all the French like to enjoy life. And I completely understand why: they have absolutely amazing food, on which they could spend a fortune. Not on cars, not on apartments, but yes on lunches and dinners. It does not have to be the newly opened restaurant, but the quality needs to be high. Furthermore, quality comes always before quantity. Naturally, to be able to fully enjoy this experience, you need to have a fat wallet. Or offer yourself a treat from time to time.

Whether that is revealing something about us or about the city, it is up to us to take the action and figure it out.

homeless people speak English (true story), there is quite a change. Even after a while, when I got used to the vocabulary used at work, the lunch breaks were the most painful part of the day. You just start believing that you speak the language, and it comes back to you like a boomerang with topics and discussions on world crisis, elections, political debates, etc. And you go back to where you were the first day you arrived.

Finally, let's talk a bit about Paris, even though a whole lifetime is not enough to discover it and tell all the impressions. In the beginning I was overwhelmed by seeing the Sacré-Coeur, strolling along the Seine or in the narrow streets of Paris, whose architecture seizes one's attention fully. After a while I got used to it, so I needed to remind myself from time

The only thing which did not disappoint me is research in photonics, which is the prime reason why I came to Eindhoven University and the road led me further to 3-5 Lab in France. This technology is the reason you are now able to read this article, listen to the music and watch a high-quality video at the same time, not having to worry about how much bandwidth is required for all of this and how much you are using at the moment. It is a commodity which would be hard to give up on nowadays.

If you are wondering how my ordinary work day in France looks like, here it is: flexible working hours, as long as you get to finish what was planned, morning coffee break, one and a half hour of lunch break, afternoon coffee and yes, there is still time to work in between these breaks. Taking into account all



DEPARTMENT

of this you can conclude that the French are

to time to stop, turn around and acknowledge where I am. Sometimes it is easy to forget due to enormous amount of people, garbage on the street, areas where you feel like in another country, but as long as you know how to appreciate the good things, Paris offers so much. From its leisure walks in the parks, visits to the castles in the suburban areas, various night life scene - from jazz, latin to traditional French music, I could say there are even too many interesting things and one has a hard time limiting the choice.

One of my favourite places is Shakespeare and the Company, one of the oldest libraries, where the first thing you notice is the smell of books and old wooden bookshelves. Even though a small bookstore, one could spend a whole day inside, as there is a part on the first floor where you can read in peace and enjoy the view on the Notre Dame through the window. If that is not enough, there is another room with an old piano, which anyone could try out and please others who came only to see if someone is playing it (yes, I do that often).

This would only be the introduction to this lively city, which has to be experienced with the right attitude. Paris holds a lot of secrets and it is up to each of us to find them out. Whether that is revealing something about us or about the city, it is up to us to take the action and figure it out.

A view of the Eiffel Tower from Montmartre and the uncertain look into the future

Internship in Korea

By: Wilco Pesselse

I'll be honest: I'm not an Electrical Engineering student, for my internship I wasn't looking for a University and I wasn't looking for a country as far as South-Korea. Still I ended up writing this story for the Connecthor at a University in Korea – and I don't regret it at all!

Ending up in South-Korea

"I'm not an Electrical Engineering student" - at least not anymore. In 2011 I started the Bachelor Automotive and thereby I was part of the first generation of this new study, officially part of Electrical Engineering. Three years later I received my Bachelor's degree and initiated student team STORM Eindhoven, to build my own motorcycle and travel around the world. Unfortunately, after 1.5 year that dream fell apart and I decided to pick up my study again. In 2016 I started my master Automotive Technology, and thereby I'm officially part of Mechanical Engineering at the moment.

"I wasn't looking for an internship at a University". After being at the university for over 5 years, I wanted to see how the industry really works and what the contribution of an Automotive Engineer can be. Therefore, I enthusiastically started applying for internships at Automotive companies within Europe, using my own and the university's network as well as applying using the endless online forms. Unfortunately, they either didn't respond at all or didn't have the place or time for me or for an Automotive intern in general – it wasn't going to work out. Time was running out so I decided that for once I was going to stick to the usual path set by the university, hence I started searching in the list of connections with other universities.



"I wasn't looking for an internship in a country as far as South-Korea". During my search for an internship at a company, I was looking outside of the Netherlands, but mainly in Europe. Being in another country within a company for the first time already seemed pretty exciting. However, since the option of being in a company wasn't there anymore, I still wanted to get the same excitement and decided to compensate that by searching for an 'out of the box' country. I mentioned this to my supervisor dr.ir. Theo Hofman, and he immediately told me about his connection with Kim Hyunsoo (김희수), professor at the Sungkyunkwan University in South-Korea. Just a couple of e-mails later I arranged my internship in Suwon, only 45 minutes south of Seoul!

Korean Culture

A couple of weeks, two trips to the Korean embassy and a fourteen hour during journey later I arrived in Korea. Immediately the country represented itself as I still know it, everything is arranged very well and people are willing to help, as long as you ask for it. With major companies as Samsung, LG, Hyundai and Kia, the country is very hightech. Travelling by using public transportation is very easy, using just one chip card for all busses, the subway and most of the trains. It's pretty cheap as well, a trip of an hour to Seoul is 2000 KRW (Korean Won), which equals 1.60 Euro. If you need a cab, you just open an app and fill in your destination, after which a cab close to you can accept your trip and you can follow him exactly until the moment he arrives. Yes, this sounds like Uber, but like everything else they made their own Korean version of it. They don't use Google but they use Naver and they don't use WhatsApp, but they use KaKao Talk, and the funny thing is, it all works very well, sometimes even better. Paying by using your smartphone is no problem and they have free public toilets everywhere, something that should be arranged in the Netherlands as well. Another gadget that must become mandatory in Holland is the heated toilet seat - it's heaven! And yes, the toilet also automatically 'cleans everything'.



Altogether Korea can be regarded as a Western country. Perhaps it's best to compare it to Belgium. Not only because of the doubtful road conditions now and then, but also because it's a bit of a mix between two different cultures. Whereas Belgium can be regarded as the mix between the organised north (Netherlands/Scandinavia) and the more chaotic south (France), Korea can be regarded as the mix between the very polite and organised Japanese culture and the rude Chinese one. This is best represented in the subway station. As the metro arrives, people perfectly line up to enter the metro organised, but as soon as de door opens they won't wait until the people get out first. In the end, you still want to get that scarce seat for yourself, right?!

While the population density of Korea does not differ a lot compared to the Netherlands (or Belgium), the way people live is very different. Whereas in the Netherlands the population is quite widespread across the country, all life concentrates itself within the big cities in Korea. This results in the main capital Seoul inhabiting over 10 million people, making Suwon just a small city, with 'only' 1.2 million people (for comparison, in Amsterdam, the biggest city in the Netherlands, live 0.8 million people). This way of living results in a very typical skyline, with a lot of flats made from concrete to house as many people as possible. This concentrated lifestyle also results in a very active environment, with a lot of small shops, coffee bars and pubs with almost a 24/7 mentality. Doing some groceries at 11.00pm or finding some fast food at 3.00am after a night out is no problem in general.

Campus life

I live on campus in a dorm, and yes, I have a Korean roommate. However, there's not much time for him to bother me, since the Korean people work a lot - I'm inclined to say they work too much. Working hours in the lab are officially from 9.00am till 8.30pm, but they usually stay until 10.00-12.00pm five days a week, and they have to be in the lab on Saturday morning as well. On top of that, it's not uncommon that the professor tells them to stay on Sunday as well. Naturally no one dares to open a discussion with the professor, since in general a professor is treated like a king. Yes, they even bow! Luckily our professor is very nice, and my working hours are 'only' from 9.30am until 7.00-8.00pm.

During these hours I work on my assignment which is 'performing a comparative analysis between a Toyota Prius and a Honda i-MMD'. Practically this means building two forward simulators in Simulink, scaling the motors to match the performance for a fair comparison and finally compare it regarding efficiency and fuel economy.

This might sound like a lot of work for just an internship, and perhaps it is. But I try to get along with the Korean culture of 'work hard, play hard'. The fact they work hard I already explained, but you get something back for it as well. About twice a week the professor takes the lab out for a dinner or lunch, and almost once a month we go on a trip





VARIAI

somewhere, mostly to do some hiking. While most people know Korea just from the capital Seoul, in which you can do a lot of sightseeing and partying, but there is a lot of beautiful nature as well. There are several national parks where you can hike on a mountain which gives you beautiful views. There are also a lot of small islands in the south which are beautiful to visit.

Koreans are very proud about their food culture as well. Almost everything is either made from or served with rice and most food is very spicy. Famous is the Korean barbecue; they put some pork on a BBQ and when it's almost done they cut it into pieces with a knife, making it possible to eat them using your chopsticks. Just as every dish, it is served with rice and comes with Kimchi 김치), a cold dish made from fermented cabbage and radish and made both sour and spicy. Also their local booze is made from rice; they drink Makgeolli (*******), a rice wine which tastes actually more like a sweet rice beer, and there is the most popular drink among young people when they go out; Soju (소주), a rather tasteless but very cheap drink, of course made from rice.

Summarizing

South-Korea is a modern country which is proud on itself, ensuring that people want you to have a good time as a foreigner. And that's what I'm doing, having a very good time. It's great to see the impressive large cities and to see the beautiful nature. By having Korean friends I'm experiencing the Korean culture, and combining that with my international exchange friends, I'm experiencing the full internship adventure – I love it.

감사합니다 for letting me stay in Korea.

At last I want to wish all Thor members a very good time during their study trip to Russia and South Korea. You will have a great time here!



Viking encryption – the Røk runestone

By: Fer Radstake

Besides being named after the Norse god of thunder, e.t.s.v. Thor has much more to do with the Vikings. The names of committees like Ivaldi and Kvasir, our fileserver Mjolnir and our pub Het Walhalla all come from Norse mythology. Our members like to behave like a bunch of Vikings too, loudly chanting the Thorlied on every occasion and cheerfully raiding the "constitutieborrels" of the other associations, never returning without some kind of loot. In short, we're a real Viking association. In this month's edition, I'll discuss something very connected to our modern digital society, but already widely known to the Vikings: encryption.

A world without encryption would be almost unthinkable. We use it to protect our bank account, to keep our passwords safe and to protect valuable data from hackers and spies. But even though encryption has never in history been more prevalent than now, it has been used since the very beginnings of history.

Cryptography first appears in history around 1500 BCE when the Mesopotamians protected a commercially valuable pottery glaze recipe by leaving out letters and using non-standard spellings. Later, the Greeks and Romans protected military orders by employing character shifting techniques. The mediaeval Arabs were the first to publish a scientific treatise on the topic of encryption. All these cultures were highly advanced societies with advanced military, scientific and economic apparatuses. Notwithstanding an individual Viking's combat prowess, the Vikings didn't have an advanced military, their contribution to science is close to zero and much of their economy depended on trade and raiding. So why then is a large part of the runic corpus encrypted?

A clue can be found in some widespread "words" that at first sight appear to be gibberish. Among these is bmkiiissstttiilll – itself a form of encryption since it's the words bistil, mistil, kistil (thistle, mistletoe, box) written through each other. The nature of these words suggests some kind of magic ritual. And there we have our answer: where the average runestone is just a funerary memorial, the magical use of runes is well-documented in contemporary documents,

and many short engravings have been found that can hardly be explained as being of any other use than magic. In contrast to the memorial engravings, these magic runes would be reserved for a religious and/or social elite and were to be concealed from others.

Now we've established the why, let's get to the how by taking a look at the famous Røk runestone. Featuring some 160 words, the stone uses three forms of encryption. The first is the simplest: the use of a different alphabet. The Røk stone was made in the 9th century, a while after the Younger Futhark had replaced the Elder Futhark as the alphabet of choice. For one small passage however, the runemaster switches to the older alphabet, by then unknown to many.

A slightly more advanced encryption method is found in another section of the runestone. Here, the so-called Caesar cipher is used. This method is named after the famed general Julius Caesar, who supposedly used it during his military campaigns in Gaul. It works by shifting each letter a predefined number of places in the alphabet, so that, when shifted one letter to the right, an A becomes a B, a B a C, a C a D and so on, until the Z becomes an A again.

The most advanced encryption however is found on a third section of the stone. Here, so-called cipher runes are used. To encode these, we have to look at the structure of the Younger Futhark alphabet, which was traditionally grouped into three ætts or families. In cipher runes, each stroke has two series of smaller strokes attached. The first of these

gives the ætt to look in, the second one the number of the letter within the ætt (see table below). Thus, a vertical line with one stroke on the left and three on the right would be the third letter of the first ætt, an M. As you can see in the image below, other shapes existed as well, although the principle remained the same.

The final form of encryption is the content however: the Røk stone consists of a number of riddles. The answers are not given however, and the text seemingly jumps from riddle 2 straight to riddle 12. Although the text has been satisfactorily translated, no scholars seem to have so far succeeded in decoding its meaning. Apart from some individual riddles, much about the stone is still clouded in mystery.

Now that I've given the basic encryption methods used, let's give a small puzzle. Below are three of the riddles as they're encoded on the Røk stone – transliterated into English of course. See if you can translate them!

ΙΤΕΛΛΘΕΦΟΛΚΤΑΛΕΥΥΟΟΦΘΕΛΙΝΕΟΦΙΝ ΓΟΛΔΥΥΑΣΡΕΠΑΙΔΒΥΑΥΥΙΦΕΣΣΑΚΡΙΦΙΣΕ

HSDKKSGDENKJSZKDSNVGNLHRANQMZ QDKZSHUDSNZUZKHZMSLZM

11111111111XX

Ætt	3				2				1							
Number	1	2	3	4	5	6	1	2	3	4	5	1	2	3	4	5
Symbol	۴	N	Þ	\$	R	٢	*	+	I	ł	4	1	₿	۳	1	۲
Transliteration	F	U	Þ	А	R	К	Н	Ν	I	А	S	Т	В	М	L	R
		W	Ð	0		G			E	Æ		D	Р			
		0	TH	Æ												

Ivaldi OHD

A lecture room full of parents enjoying a lecture was quite a pleasing view for our committee, as we organized and were responsible for every bit of content of the day. We could finally enjoy the activity we organized for the last four months. The first year committee Ivaldi organizes the Open House Day (OHD) on yearly basis for parents to feel what it is like to study Electrical Engineering or Automotive, as their son/ daughter does. This year's edition was on Friday, February 17th.

The day started at 8 o'clock for the committee, two hours before the parents would arrive, which gave us enough time to prepare for the day. There was enough to do to fill this time, including making coffee, receiving Albert Heijn groceries and making sure parents would be able to find the colloquium room on floor 6 with signs. All six organizers had a detailed schedule to prepare for every part of the day, to ensure the activities would run smoothly and without any problems. After the reception, we welcomed the parents and shared the schedule for the day.

The first part of the program was the lecture, split into two parts with two different speakers. The parents were escorted to the Zwarte Doos, the lecture hall of the day. The dean of Electrical Engineering and Automotive, A.B. Smolders gave a short presentation about the two bachelor programs in general and the university. He was followed up by Mr. Kuipers, who told about basic electronic components and circuits with lots of enthusiasm and humor. The entire lecture was built around the circuit used in the case later on the day. I

only witnessed 10 minutes of the lecture. It's quite funny how you can organize a day like the OHD and still miss half of it because of just that. In this case, because we were busy with the preparations of the lunch.

After the lunch in the colloquium room in Flux, we split the parents in two groups. The first group got an assignment to apply the theory from the lecture in a case. The other half of the parents received a tour through Flux and the TU/e campus in two groups. The tour included a tour through the CWTe lab (Centre for Wireless Technology). The tour ended with a pub quiz in "Het Walhalla", which included questions from other courses, so the parents would get in contact with the courses which were not discussed in the lecture and case. The pub quiz contained questions about Eindhoven and the university in general too. The groups switched afterwards: the first group got a tour and the second group started with the case. Both the case and tour wouldn't have been possible without the help of other students who gave the tour or guided the parents with the case.

The OHD was closed with a drink in "Het Walhalla". Many students met with their parents after their lecture, which made the drink even better.

Looking back at the event, we believe it was a successful day. Not everything went according to plan, but we were able to fix all problems without them affecting the day. Organizing an event like the OHD taught me a lot. I learned to set up well organized meetings, distribute and complete action points



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during meetings and found out organizing a day like this involves more than I expected beforehand, but I enjoyed the OHD and liked organizing it a lot. I hope next year's Ivaldi OHD organization will learn from this year's problems and will enjoy a lecture room full of parents just as much as I did!





IDEPARTMENT

Optical wireless communication

By: Ton Koonen, ECO group, Institute for Photonic Integration

On March 9, 2017, Joanne Oh obtained her PhD degree with the extraordinary Cum Laude distinction, on her thesis "Free-Space Transmission with Passive Two-Dimensional Beam Steering for Indoor Optical Wireless Networks". First promotor was Ton Koonen, and co-promotor Eduward Tangdiongga, both of the ECO group.

oanne's research was done in the framework of the project BROWSE - Beamsteered Reconfigurable Optical-Wireless System for Energy-efficient communication. This is a project funded by an Advanced Investigator Grant of the European Research Council, obtained by prof. Ton Koonen, chairman of the ECO group; it started in Sep. 2012. In the BROWSE project, a novel indoor network is being investigated, which uses narrow beams of infrared light for establishing high-capacity wireless connections to portable devices such as laptops, tablet computers, smartphones, etc., and also to (movable) high-bandwidth devices such as large video screens. Next to the infrared beam techniques studied by Joanne, the BROWSE network uses a flexible fibre backbone network carrying the high-speed optical signals to the beam-emitting optical antennas, and carrying also the upstream data from the devices carried by 60GHz radio waves which are converted into optical signals at the antenna. By means of these radio techniques, also localization of the devices is done in order to direct the downstream infrared beams to the devices. The BROWSE system features the centralized intelligence functions needed for the network control and management as well , in order to direct the signals to the right room and to the right place inside the room in response to the communication requests from the users' devices. In total four PhD students are involved in BROWSE: Joanne Oh (ECO) for the optical wireless transmission with the steerable optical beams, Ketema Mekonnen (ECO) for the flexible fibre indoor



network, Bindi Wang (MsM) for the 60GHz upstream wireless communication and localization, and Maria Torres Vega (ECO) for the network intelligence functions. Next to them, technician Frans Huijskens, and post-docs Fausto Gomez-Agis and Amir Khalid (now with Philips Lighting) are working in BROWSE.

The need for wireless connectivity is booming. Smartphones, tablet computers, laptops, they all are asking for more and more data, and do so in rapidly increasing numbers. Today's Wi-Fi networks are struggling to handle this explosive growth in demand, and we can



experience this on a daily basis when we (again) get a slow Wi-Fi connection or maybe not even a connection at all... Typically, a Wi-Fi station has to serve a large area (such as a complete house, big office, airport waiting lounge, train wagon, ...) and the many devices within that area have to share the capacity (typically some 300 Mbit/s) of that single station. They are competing by means of a MAC (medium access control protocol) for their share. Consequently, if one device wants more capacity, another one gets less; it is like a big pie which you have to share with the other guests. Hence you cannot be assured of a reliable capacity. Moreover, Wi-Fi is working at radio carrier frequencies in the 2.5 or 5GHz range, and there is only limited bandwidth available there. More bandwidth can be found at higher frequency bands, such as in the 60GHz band (57-64GHz). But in the optical domain much higher frequencies are available: the 1.5µm wavelength (popular in fibre optic systems) corresponds with a carrier frequency of no less than 200THz, and the range 1.5-1.6 µm with a bandwidth of 12.5THz (!). Several research groups are investigating visible light communication (VLC), where use is made of existing LED illumination by using the LEDs next to their primary lighting function also for sending data by

modulating them. As the LED system is typically designed to illuminate the whole room, and these LEDs are not primarily designed for high-speed illumination, the data capacity is limited and, moreover, has to be shared with all the devices in the room, so again bringing the 'pie-sharing' issue. Plus that you have to switch on the LED illumination in order to have VLC communication, which you may not always prefer to do (e.g., when sunlight is nicely shining into your room, or you want to have the lights off for other reasons). It also requires extra energy when you only want to communicate, without illumination. In our BROWSE project, we have therefore opted to use narrow infrared beams of light. Upon request, each device in the room gets its own beam, so the full capacity is solely devoted and guaranteed for him ('he gets a full pie only for himself'). Moreover, infrared light (IR light, with a wavelength beyond 1.4 μ m) does not penetrate the human eye, so there is no eye-safety problem up to power levels of 10mW (whereas with visible light beams this threshold is much lower: cf. laser pointers which already at 2mW can cause permanent eye damage...). And as the beams only are directed to where the capacity is required, and as you do not use the illumination, the IR beam communication is more energyefficient.

As illustrated in the BROWSE network concept in Fig. 1, within each room we have so-called pencil radiating antennas (PRAs). These are preferably are mounted on the ceiling and from there can emit multiple IR beams. By having at least two PRAs per room, blocking of a ray path from a PRA can be avoided because another PRA can take over. The PRAs are connected to the fibre network, from



which they receive the remotely generated high-capacity light signals. A PRA contains a specific fully-passive optical structure, which diffracts the light signal in a two-dimensional direction depending on the wavelength of that signal. Multiple beams can be generated by the same PRA by just feeding multiple wavelength signals to it, and each beam follows a direction determined by its wavelength. Thus the wavelength carrying the data is also controlling its direction: the control channel is embedded in the data channel. and does not require a separate channel. The wavelength signals are generated by wavelength-tunable laser diodes (well established in optical fibre communication systems), which can be remotely located at the centralized communication controller (CCC, see Fig. 1). This considerably eases the management of the network. Scaling up the network to more beams is also simple: just add extra wavelengths, the fibre network can guide many of them. Other groups have looked into beam-steering techniques too, e.g. by means of MEMS (micro-electromechanical systems) mirrors, or spatial light modulators (SLMs); then each extra beam requires an extra mirror or SLM, plus the control signal for it.

Using such IR beam at 1.5 µm and a diffractive structure with crossed gratings, Joanne achieved the transmission of 42.8Gbit/s over a distance of (at least) 2.5 meters, which is more than 100x the capacity of a 300Mbit/s Wi-Fi station (which on top of that most likely is to be shared...). Just to give this 42.8Gbit/s number some extra meaning in the consumer environment: a high-quality film on a DVD has some 5Gbytes of data, which is 40Gbits, and can thus be downloaded within 1 second in your laptop, by your individual IR beam. And

DEPARTMENTI



somebody sitting next to you can in the same second download another 5Gbytes film, via his/her own beam...

Optical wireless communication using infrared steerable beams thus can offer a tremendous capacity, and holds great promise to offload the high-demand burden from Wi-Fi systems. It will not fully replace Wi-Fi; e.g., IR light needs line-of-sight, so cannot reach your smart phone hidden inside your clothing. This research is done in the Institute for Photonic Integration, and is yet another research branch underlining the rich potential of optical communication!

P.S. Following Joanne's PhD graduation on March 9, there has been much media attention in the national and international newspapers, websites, TV and radio programmes; see/hear e.g.

- BBC Radio Breakfast News http://www. bbc.co.uk/programmes/p04x305l
- VTM TV https://nieuws.vtm.be/cultuurmedia/met-deze-wifi-surf-je-100-keersneller
- NOS Radio 1 journaal http://nos.nl/ artikel/2163614-razendsnel-alternatiefvoor-wifi-infraroodstralen.html,
- RTL Nieuws, NRC https://www.nrc.nl/ nieuws/2017/03/30/wifi-met-infraroodlicht-haalt-in-een-seconde-een-helefilm-van-internet-7776324-a1552526,
- Algemeen Dagblad http://www.ad.nl/ eindhoven/tu-eindhoven-ontwikkelthonderd-keer-sneller-wifi~a8eca557/
- Telegraaf http://www.telegraaf.nl/ digitaal/27826110/__Honderd_keer_ snellere_wifi_door_infrarood__.html
- nu.nl http://www.nu.nl/ internet/4548366/nederlandse-onderzoekers-maken-supersnel-lichtnetwerkdata.html
- Science Daily https://www.sciencedaily. com/releases/2017/03/170317102428. htm

IASSOCIATION

ODIN trip to Belgium

By: Sjoerd van der Heide

ost of the readers will probably have heard of ODIN in one way or another. However, if you have not, we do not blame you. This year, ODIN became active again as a master association of Thor and organized educational activities such as lunch lectures and excursions related to the research profile 'The Connected World'. Also, many appreciate the coffee we make every Monday morning, a time when the board of Thor is not available due to their weekly meeting. Unfortunately, ODIN did not organize many activities for the past couple of vears. In contrast, this year we decided to go for it and organize one of the most notable activities one can organize: a trip abroad.

Starting on Thursday April 27, King's Day, we went on a four-day trip to Belgium. Thirteen participants gathered in high spirits to start the trip. We drove with two minibuses towards Belgium and upon crossing the border changed the station to Studio Brussel. Studio Brussel is known for their random taste of music, playing rock music after classical and dubstep after metal without a care. The spirit during the road trips proved to be one of the many highlights of our trip abroad.

The first visit was to CommScope near Leuven. CommScope makes optical connectors and short range optical combined optical fibers and sell complete connectivity solutions. They recently acquired the optical activities from TE Connectivity, including their fiber routing machines that were situated in Den Bosch. We were welcomed with a cup of coffee and a presentation about their activities at the site. Afterwards, we were able to walk through their production and R&D facilities. Material





labs, 3D printing, product testing, optical routing and more activities were introduced and explained.

We continued our journey towards Ghent. After spending some time in the Belgian traffic jams, we arrived at our place to stay for the coming nights: a hostel near the center of the city. We contacted a technical study association in Ghent beforehand. They wanted to welcome us and explain their role in the university. Unfortunately, due to time delays in the company visit and the traffic jams, we were too late to do this. Fortunately, they have their own bar which we were able to visit. Upon entering the building, we immediately had nostalgic feelings to our old bar in Potentiaal because of the typical scents. We enjoyed the fine Belgian beers and participated in games. Ghent is a true student city with an approximate 40 thousand students.

This was also apparent later at night when the district we were in was swamped by students from all over town.

The next day we had the beautiful job of waking everyone up on time. After some loud noises and shouting, everyone turned up at the breakfast table on time. With breakfast and a couple of coffees in our bellies, we drove to the Ghent University. We had a busy afternoon with many talks about various subjects. We started with a talk about Data Efficient Machine Learning, a technique where machine learning is used to model a certain process with as little data as possible; the opposite of Big Data. One of the applications is when you want to do a multi-dimensional parameter sweep of a certain expensive (slow) simulation. The model chooses the most effective parameters to run the simulation. Instead of using a grid of parameters to sweep, it adjusts the distance between





parameters in order to make the parameter sweep fast and numerically accurate. It creates a model of a model. The best thing is: the software is free for academic use. Ask us or one of the participants if you want to know more!

That was just one of the presentations we had at Ghent University. I do not have the space to elaborate on them all. The other talks were on Network Modelling, High-speed Electronics and Silicon Photonics. Afterwards, we walked past their clean rooms and saw a couple of their labs. One of the techniques explained was the flip-chip bonding of III-V-materials such as InP on silicon-on-insulator to combine the advantages of silicon photonics to III-V's ability to have optical gain blocks. The program of the rest of the day was up to the participants themselves. Many went to the city center to have dinner and drink a beer in one of the many cafés.

Whereas Thursday and Friday were full of educational activities, Saturday was used for cultural activities. We went to the medieval

Gravensteen castle, which was only occupied once. In 1949, students took the castle because they were angry about the rising beer prices. And after a couple of days, when they ran out of beer, they gave the castle back. Currently it is a museum for medieval torture equipment. In the afternoon, we had a guided tour through Ghent on a boat. The guide showed us the most important buildings of the city and their role in the past. It was interesting to hear what went on in the city and what the symbolism on the facades of the buildings meant.

The boat dropped us off at the Gruut brewery. They organize brewery visits with a couple of tasters and explained us how they make their beers without hops. Also, they told about the history of these kinds of beers in the region. We went on to eat a spare-rib dinner after the brewery visit. All participants joined in and tried to do their best. The evening was concluded with a beer in one of the bars.



ASSOCIATIONI

A couple of days before our visit, a member of Thor visited the city and the brewery as well. He left ten stickers for us to find all over town. The entire day, we were trying to find the stickers. He placed quite a few near the brewery and others in the city center. We managed to find eight of them. Whoever goes to Ghent in the future, try to find Thor stickers with ODIN stickers above them! It is a nice search throughout the city.

On Sunday we split up. Part of the group went home as planned, the others wanted to do a little detour. They went to De Halve Maan brewery in Bruges. It was the perfect ending for a four day trip to Belgium. We managed to combine educational and cultural activities into a nice trip. ODIN organizes activities more often, both educational and other. If you are interested in joining one of our activities or organizing one yourself, please let us know. You drop by on the sixth floor to drink a cup of coffee or reach us via e-mail at ODIN@tue. nl. Memberships are possible for (end of) Bachelor and Master students and PhD's.



DEPARTMENT

Book my space

A new methodology for swift and easy reservations

The new Book My Space platform makes it easier for students and employees to find and reserve meeting rooms and study places / workplaces themselves. It concerns the reservation of rooms, study places and workplaces made available across the whole campus, both in advance and on the spot. This can be done without the intervention of a secretary or receptionist, for instance, and without various procedures, methodologies or systems which may now still differ per building. With the introduction of Book My Space in Flux the roll-out in all buildings of the compact campus is almost complete. Currently Book My Space is also looking at the possibilities of reserving at the buildings Luna (The Plint) and Atlas.

Why this new methodology?

With the arrival of the Bachelor College and the Graduate School students and employees are no longer exclusively bound to their departments or organizational units. Working in a time- and location-independent manner (Innovation@work) has increased the need for a quick insight into the available study places/ workplaces or meeting rooms.

From a viewpoint of efficiency and convenience for users, TU/e has decided to make the search for and reservations and use of rooms available to all 'residents' of the TU/e campus, and to make it simpler. Employees as



well as students are enabled in advance or ad hoc to find and use an appropriate room, by means of a room policy, a uniform TU/e-wide methodology and supporting systems.

By means of a uniform room reservation system (Book My Space) employees and students with TU/e user accounts can find and reserve workplaces / study places and meeting rooms across the whole TU/e campus.

Reserving

Wavs of reservina

As an employee or student you can continue to reserve by means of Microsoft Outlook just like you used to do. The benefit of reserving through Microsoft Outlook is that you can plan an appointment for more persons at once.

The Planon SelfService is especially handy if you need to find and reserve a room with special facilities. You get a quick overview of suitable rooms, for instance if you are looking for a room for a larger group of people or a room with a beamer, audio installation and such.

With the Planon app, which must be installed on your smartphone beforehand, you can claim a free study place/workplace or meeting room at the moment when you arrive. You do so by scanning the QR code that is posted at the study place/workplace or meeting room by means of this Planon app.

You can also make reservations with this app via a tile on the app.

Education

Education has priority upon booking the teaching rooms. If a teaching room should still be free one week prior to the date planned by you, you can reserve it yourself.

Overruling

If necessary, a number of employees (reservation managers) can 'overrule' the reservations and offer you another room. These employees can also help you find an alternative room, if necessary.

Manaaement

The management of the room reservation system has been organized efficiently; one

By: Antoinette van Voort and Corine Spoor



management organization for the system has replaced a separate management system per department/organizational unit or building. These managers make use of the software Planon ProCenter.

Support

Book My Space is being facilitated by the Internal Affairs Department and Real Estate Management.

More information can be found on the Book My Space website. For questions or comments you can email the Helpdesk or call (040 247) 2926.

Flux and Book My Space

Upon the introduction of Book My Space in Flux we have carefully considered the reservation concept and decided to temporarily deviate from the standard. After some time evaluation of this process will take place.

Because the bookable rooms in Flux have a relatively high occupancy rate and because the rooms in Flux are inhabited by several people, the need for available meeting rooms is greater than in the more traditional buildings. For this reason, it has been decided to only include the conference rooms in the pool

of available spaces for all campus residents. All other meeting rooms are only bookable by employees of EE and AP. The Design-Based Learning (OGO) rooms are only to be booked by EE and AP students and staff.

Book My Space and Evoko

In Book My Space some features return that we were already used to use via the Evoko screens in Flux. In order to prevent that double bookings occur, some of these features are no longer available via the Evokoscreens, but via Book My Space. For example, direct bookings can no longer be done via the Evoko screen, but only by scanning the QR code. This applies also to, for instance, the earlier termination of a meeting or finding a room nearby. It is also no longer necessary to confirm the room reservation at the start of the meeting. The risk of "no shows" is therefore somewhat higher.

Reservations in other TU/e build-

ings Students and staff of EE and AP can make reservations of meeting rooms and study/ workplaces in Flux, but also in the other buildings of the compact campus.

Future

Book My Space strives for continuous improvements in various fields.

Internet of Things

Sensoring will be deployed as well. Thus the actual use of the reserved space will be recorded. After a period of time the room will be automatically released for reservation by another user if no activity is detected.

Software adjustments

In order to further enhance the possibilities of room reservation adjustments to the software will be done in in the future.

Two 3E-Royal Smit BSc Awards for TU/e

Thursday 16th of March, Birgit van Huijgevoort and Bram Hooimeijer attended the finals of the 3E-Royal Smit Bsc Awards. Every year, this award is handed out to the best Bachelor theses in the field of Smart & Sustainable society. Birgit and Bram won 3rd and 2nd place respectively.

he award is an initiative from Royal Smit transformers, a Dutch company concerned with everything from research to production of transformers. In order to support research in energy technology, they hand out the award every year to bachelor graduates from both academic as well as professional universities (HBO).

The CEO of Royal Smit, Ernst Knoll, welcomed the nominees and their support in the Jupiler lounge of the N.E.C. stadium in Nijmegen with an introductory talk about the company. Then the finals began. Beforehand, the 3rd prizes were decided upon. For the 1st and 2nd prize however, the nominees had to defend their thesis. Ten minutes, in front of eight jurors, they had to explain their months of work understandable for both experts and laymen alike.

Guido, from Hogeschool Rotterdam, started off with his talk about switching schemes of inverters. He optimized the power loss by applying a different switching scheme. He was followed by Karolina, explaining how she investigated security measures in power distribution.

Most difficult in such a defense is making sure that your story matches your audience, especially when it is so diverse as this one was. My thesis covered CO2 dissociation using plasmas, a topic which requires quite some perguisite knowledge. A juror like Guus Pemen is as familiar with plasmas as can be, while the family I took along as support has never heard of plasmas at all. My foremost goal for the day was ensuring that my support could follow the presentation as well, and I succeeded!



All nominees for the 3E-Royal Smit Bsc Award. Front row from left to right: Guido, Birgit Bram, Renzo, Karolina, Jan, Lou van der Sluis (Juror from TU Delft), Suzanne, Ernst Knoll (Royal Smit) and Theo Ykema (3E).

DEPARTMENT



By: Bram Hooijmeijer

After consultation, the jury decided to award the first place to Renzo, an electrical engineer from TU Delft. His thesis, which he conducted in a team of four, covered the power output of shaded solar cells. Solar cells are connected in series, and hence have a very bad power output if one of the cells is shaded. By devising a new topology including parallel connections between cells, he managed to increase power output tremendously. Birgit, having finished Automotive in Eindhoven, took home the 3rd place award for her research on Modeling and Control of a Formic Acid Powertrain.

IPUZZLE

Puzzle

26	35	37	
31	36	39	
38	26	24	



Objective / Rules

On the left is a very special grid, around

each shaded number are 8 white squares. However, each white square should have

a number from 1 to 7. Once filled in, these

8 numbers will sum to the shaded number.

In addition, once completed correctly, no row nor column will contain a duplicate

Please send your answer to connecthor@

The winner of the previous puzzle is Tom

van Nunen. See the right page for his

number within a white square.

thor.edu before 8 July.

Whose desk is this?

The author is: Kees Goossens.

Winner previous puzzle

column!

Let me help you get bright

ome people need some extra attention. Some people need the extra push. Some people just need someone to look over their shoulder. I must say I really like to assist in those situations.

The first few years of university I worked as a homework assistant for secondary school students. There was a private bureau with one former teacher who knew all students personally and helped them with their planning. She had a pool of university students, each with his/her own competences, to whom she would send a student if needed. Together with two others, I was responsible for biology, chemistry, math and physics. Each week I would see three students for our regular appointment, and around the exam weeks this could sometimes double.

Apart from the money I earned from this job, I just really enjoyed it, especially the growing curve that I could observe in every one of them. Apparently the students felt comfortable around me and apparently they liked my style, whatever that was. It made me feel good that I knew that I was doing a good thing, that I was adding something, albeit small, to the student's life.

Nevertheless, I wasn't always just their teacher. Quite often - we observed this together with the other assistants - the student seemed perfectly capable of solving the homework. They didn't need that much explanation and they also didn't make strange mistakes during their assignments, in fact they would sometimes even show a high level of understanding. Why on earth would they go through all this time and money for 90 minutes of extra teaching?

We assume it wasn't so much for the teaching itself that they wanted to come over, but rather about the safe environment we created: nobody around them to judge them, no distractions and someone to force them to spend their time on the subject and to guide them in the right direction.

The university also offers students the possibility to work as a tutor for instruction sessions. I've been doing this for a couple of years now for a total of four different courses, and I must say that I enjoy it a lot. It's different



than the private homework assistant job, but it is satisfying, not to mention the fact that the salary is more than welcome.

In my years as a teaching assistant (TA), I've collaborated with many other students. It's interesting to see the different approaches. Some really take the time for a question, whilst others try to answer as quickly as possible so they can go back to chatting with others. Some don't directly answer a question, but try to guide the student to the answer by asking questions, whilst others give the answer directly or, alternatively, say that the student is assumed to already know the answer and hence will receive no further help.

It's clear that some people are more suitable for the job than others. Some really do this because they like to do it, they enjoy helping

VARIA



other students and to see them gain knowledge. One could almost say that it's their passion. Others do it for the money or are simply not built for the job. Most of the time, the students can tell the difference clearly, and unfortunately sometimes they carefully pick the right moment to raise their hand, when their favorite TA is near.

In general, I'm happy that the university enables us to work as a TA. It relieves the teachers from some pressure, lots of students are suited and enjoy doing it and also some extra money is always welcome. It's a pity that not every TA is as good as the next, but as long as this doesn't cause big problems, it's fine by me. 🗖

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