TU/e
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Magazine of e.t.s.v. Thor and the department of Electrical Engineering at Eindhoven University of Technology
March 2019

Women in Science Eindhoven | Inaugural **Lectures**

Integrated Photonics| Rock Your Baby | Career after TU/e

Connecthor

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You've just opened and started reading a well-filled Connecthor magazine, the March edition. As you may know, the Connecthor is a combined student and staff magazine. This means that it is not only made by students and staff members, but also read by student and staff members (scientific and non-scientific personnel). This first edition of 2019 is a prime example of this happy collaboration.

First of all, we start off with the summary of our dean, Bart Smolders, his speech at the New Year's gathering on January 7, 2019. He mentions the many highlights of the year 2018 and also gives us insight into the expected growth that will start in 2019. You will find out more about his speech in the Board Issues section.

As you might know by now, we are very proud of the achievements of the people in our department and the work that they do. Massimo Mischi and Mark Bentum both held their inaugural lectures in December 2018. We are honored to share a shorter version of their inaugural lectures with you. Massimo Mischi's article about human intelligence in biomedical diagnostics starts on page 22. Mark Bentum's article about Space-based radio astronomy can be found on page 32.

We are at the edge of a new technology that is going to conquer the world: Integrated Photonics. Please read more about what Ton Backx has to say about it.

Debashis Dhar writes about his PhD research on a complete 3D Microwave camera.

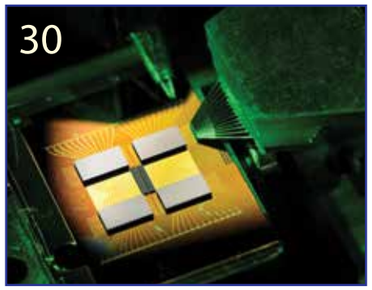
Some of you are probably very curious as to what students do after they have graduated. Therefore, a new item is added to our magazine: "life after graduation". Christopher Geelen, alumnus, shares his story about his career thus far after earning his Master of Science title in 2014.

We hope you enjoy reading this March edition.

The Connecthor editorial board.

P.S.: The Connecthor editorial board has positions open for creative and enthusiastic employees of the Department of Electrical Engineering interested in joining us to make the Connecthor magazine. Up for a new challenge? Please contact us!! As always, we will be glad to receive your suggestions and nominations for the 'vlaai' and ideas for upcoming editions. You can contact us via connecthor@tue.nl. ■

Train surfing in Mauritania
Read all about Sander his trip through part of the Western Sahara on page 16



Integrated Photonics
You can read all about the future of integrated photonics on page30

Internship Abroad
Still wondering where to go for your internship? You can find a good example on page 28

Space-based radio astronomy
We recently started a space based chair on the university, namely Radio Science. On page 32 you can read Mark Bentum his inaugural lecture about this subject.

New year's speech

By: Bart Smolders

Dear colleagues and students of Electrical Engineering,

First of all, let me wish you a happy and healthy New Year. I expect 2019 to be a year with a lot of opportunities to further strengthen our department. Last year was a kind of "in-between" year, in which we continued to grow in total number of students and scientific staff. We were again successful in acquiring external funding, with a spectacular end of the year with eight granted NWO projects in December 2018 in our Flux building: four projects in our department and four projects awarded to our friends of Applied Physics. Another highlight was the renewal of the accreditation of our PDEng program DEES for the next five years. The committee members were very positive about the quality of our PDEng graduates and they appreciated the embedding of the trainees in the capacity groups of our department. A new large event in 2018 was Momentum, where all TU/e bachelor graduates received their diploma. At this event, we also received two prestigious TU/e awards: the best PhD award was received by Fons van der Sommen from the SPS group, and the best PDEng award was received by Rabia Syeda from the EM group.

2019 will be the start of a spectacular growth of our department. Our first-tier budget (which we get directly from the board of the university) increased by 3 million euro as compared to 2018. In addition, we will get extra budget from our government (as part of the 'Sectorplannen') to strengthen fundamental research in Electrical Engineering. As a result, we expect to be able to hire about fifteen new scientific staff members, ranging from assistant professor to full professor. In this way, we can reduce the workload and explore new research directions. Next to hiring new scientific staff, we will also use part of the extra budget on additional teaching assistants and PhD-plus positions (5-year PhDs). Main worry for the near future concerns the recruitment of all these new staff members. We decided to hire a dedicated recruiter to manage this process and to support the groups in their search for new talent. The strong growth of both Electrical Engineering and Applied Physics creates a new problem: the availability of workspaces in our Flux building. At this moment, we are exploring several long-term solutions within and outside our Flux building, but on short term we will need your flexibility. ■

From the President

By: Dana de Vreede

I often think about all that has changed in my life recently, including, of course, becoming Board of Thor. Within this Board year I have gotten the chance to do all kinds of things I would otherwise not be able to do. This, of course, did not come as a surprise, since it was one of the reasons I wanted to take on this challenge in the first place. However, there are a lot more changes I had not seen coming, maybe because I had not thought about them that thoroughly, but maybe also because I could not have realized the impact on my life until it truly happened to me.

One of the most obvious changes is, of course, the way I spend my time every day. Where for the past years, I joined lectures and worked on some exercises during instructions followed by a meeting of a committee, this year, my day is completely different. It usually starts with about half an hour of something related to coffee. I am either making coffee to start up all the early-bird students of our association, or I am listening to a conversation about what is the best kind of coffee. I am still amazed at how long and especially how many times people can talk about this subject. But it is a change I could have seen coming and one I am used to right now.

Another big change is what I expect of myself, and maybe even more what I expect of others. Where studying can be seen as very individual, outside of the group projects, a Board year is mainly focused on teamwork. This also explains why I and the other Board members depend so heavily on each other. We also expect hard work from each other, maybe sometimes we even have too high expectations. I am happy to say that I can see that all of us work as hard as we can, and I am proud of what we have been able to put together until now.

This also shows the other big change of this year. Not only have I gained a group of Board members, but also a group of amazingly good friends. It is something of which I had not truly realized how important it could be and how much it could affect my life, but I am happy it happened.

I have also met a lot of new people during this year, even more than I could have thought of at the start of this year. For instance, all members of the Boards of the other study associations and, of course, a lot of new students. This year, I am helping a group of first year's students set up the annual open house day for all parents. I truly enjoy my meetings with this group, and I am amazed at how easily they understand some of our ways of doing certain things.

This made me realize that I am not at all the only one who is dealing with change and the results of those changes. Every day, small or even large changes happen in our lives. Sometimes we notice them, like finishing your studies, moving to another city, or maybe even starting a Board year, but there are also enough changes we don't even notice. Think for instance about meeting someone new, finally understanding that one thing about that one course, or the fact that every day you get a little bit older and maybe even a little bit wiser. It seems like change is in fact inevitable, as has been said a lot. But maybe that is not such a bad thing, maybe it is even something to look forward to.

Veel Gedonder
Dana de Vreede
President of Thor ■

Ius Promovendi appointment

On January 15, 2019, all associate professors of the departments of Electrical Engineering and Applied Physics have received the official letter that confirms that they have been appointed "Ius Promovendi" as of October 1, 2018.

Electrical Engineering
Pieter Harpe
Henk Huisman
Mircea Lazar
Peter Smulders
Eduward Tangdiongga
Pierre Cluitmans
Alex Alvarado

Not in picture
Rob Maaskant
Oded Raz
Roland Toth

Applied Physics
Jos Haverkort
Rob van der Heijden
Henk Huinink
Servaas Kokkelmans
Edgar Vredenbregt

Not in picture
Jan van Dijk
Carola van Pul

Graduates November 2018

Peter van den Hurk
Thomas Meijer
Rik Baeten
Wil Verhoeven
Marcella Gunther
Sander Klomp

Congratulations!

TenneT excursion to Borssele

By: Bram Lustenhouwer

On the December 4, 2018, we went to the new TenneT offshore grid in Borssele. This station is one of the three new stations that connect the offshore wind park to the high voltage grid of the Netherlands, converting the 220 kV of the wind park to the 380 kV high voltage grid in the Netherlands. Before we took off with a bus to Borssele, we had to do a test for safety reasons, as they are working with high voltages, and it was still a construction site.

The group of students was split in two groups, one group got a tour around the construction site, and my group started with a presentation on why they were building this site. According to the Paris agreement of 2015, the Netherlands needs to reduce their CO2 emissions. In 2023, 16% of the Dutch energy supplies must come from renewable energy sources. Therefore, the government gave the order to build more offshore wind parks by 2023. When this park is finished, it will provide 1400 MW in total, consisting of 2700 MW offshore parks (Alpha and Beta). Of course, there are some delays when building this site, for example with delayed building permits, or the problem that they cannot get the cable, connecting the wind park to the transformer station, to the Netherlands. There was not enough water in the Rhine to transport the cable from Köln.

After the presentation and a great lunch, the groups swapped places, and we went to see the station itself. The station consists of two parts, one part for the Alpha park and one part for the Beta park. The two parts are an exact copy of each other, converting the 220 KV coming from the parks to 380 KV of the Dutch energy grid. It was quite a sight to see, walking past high-voltage cables (which were not in use yet) and seeing the massive transformers. On the site they told us about the dangers of building this site. One small mistake can have disastrous consequences. It was amazing to see and to hear what they have done to prevent those mistakes.

The full station is set to be operational in 2020, and the government ensures to have met the Paris agreement in 2023 with the Hollandse Kust south and north parks, which are still under construction. ■

Introducing...

Hello everybody! My name is Andrea Cremasco, and I come from Pavia, Italy. I have just started my PhD as a member of the EPE group, motivated by interest in advanced research on medium frequency transformers. This is not my first research experience. After getting a MSc in Electrical Engineering I spent the last four years working in Switzerland as R&D engineer in ABB, focusing on dry-power transformers and inductors. This was a really exciting period, since I had the opportunity to work on both electromagnetic and thermal topics, so do not hesitate to contact me if you share the same interest. Music is my other great passion. Since my childhood, I've liked to listen to and play music, acoustic and electric guitar, possibly with other people but also by myself. I used to play different music styles with several bands. My favorite styles are grunge, psychedelic rock and acoustic folk. I like skiing, hiking and sailing (maybe one day I will experience the North Sea). I really like cooking, not as a pro, but rather as an alternative way to relax or share time with friends.

Hello everyone! My name is Qihao Yu. I was born in 1995 in Quzhou, China. I received my Bachelor's degree in Electrical Engineering at Zhejiang University in China. In 2018, I got my Master's degree in the EPE group, at the TU/e. Recently, I started my PhD program in the EPE group.

I did my graduation project at Prodrive Technologies. It is interesting and nice to see that my research is valuable and will be adopted in their upcoming products. Therefore, I am determined to keep the corporate aspect in mind when doing my PhD research. Currently, my research topic is a RF bias voltage generator for plasma chambers.

Hello everyone! My name is Samaneh Babayan-Mashhadi. I was born in 1984, in Mashhad (One of the most populated cities of Iran). I was interested in Electrical Engineering, so I got my BSc, MSc and PhD in design of low-power, low-voltage Analog and Mixed-signal integrated circuits (ICs) all at Ferdowsi University of Mashhad. In 2009, I started my first career as an assistant professor in Imam Reza International University (IRU). I always feel proud when reminiscing my smart students and the good memories I have from my electronic classes. In 2017, I came to the Netherlands (Delft), TU Delft University, to do a post-doc research project on designing an Analog-to-Digital converter for cochlear implants. Both from technical points of view and also in my personal life, it was an amazing experience for me. After successfully finishing the project, I recently started a new post-doc at TU Eindhoven, on designing the Antenna and front-end circuitry for the application of low-frequency radio astronomy, which is an amazing topic and has opened my eyes to the great world of astronomy and its challenges.

In my free time, I like playing the piano, reading literature and psychological books, do watercolor paintings, and, of course, playing with my four year-old daughter, who has recently started to go to school and learn the Dutch language. My family and I are excited to start a new chapter in our life in the Netherlands in the hope of being useful engineers for humankind.

Hello, my name is Patrick Koelewijn. I am 23 years old and I am a first year PhD candidate at the Control Systems group of the department of Electrical Engineering here at the TU/e. I received both my Bachelor's degree in Automotive and my Master's degree in Systems and Control here, in 2016 and 2018 respectively. During my Master's degree, I spent three months at the Institute of Control Systems at the Hamburg University of Technology (TUHH) working on the topic of LPV control of a gyroscope with inverted pendulum under the supervision of prof.dr.ing. Herbert Werner. For my Master's thesis, I worked on the topic of nonlinear tracking and rejection using LPV control under the supervision of dr.ir. Roland Tóth. For my research here at the university I will focus on the topic of LPV modelling for controller synthesis, also under the supervision of dr.ir. Roland Tóth.

I have been in the Netherlands for more than two years. I live in Eindhoven now and share a house with six housemates from different countries. I enjoy living and working in such an international environment. I am also learning Dutch and trying to pick up some other languages. In my spare time, I like watching and playing basketball, travelling, and visiting all kinds of museums. I am really looking forward to the new adventure here.

Subsea cable for sustainable electricity

By: TenneT TSO BV

On November 9th the cable for the subsea electricity connection between the Netherlands and Denmark was brought ashore in Eemshaven in the Netherlands. From the ship Ulisse on the Wadden Sea, the cable was pulled ashore via a duct installed in the sea wall for that purpose. The cable will then be connected to the converter station that was built 1 kilometre away in Eemshaven. This so-called COBRAcable is a joint project implemented by Dutch TSO TenneT and its Danish counterpart Energinet.

Cable installation

Cable manufacturer Prysmian is responsible for manufacturing and installing this 325-kilometre-long electricity cable. The cable, which has an aluminium conductor with a cross-section of 2500 mm^2, has a total transmission capacity of 700 MW at a voltage level of 320 kV DC. The diameter of a single cable is 147.3 mm; its weight in water is 30 kg/m. The cable connection consists of two bundled high-voltage direct current (HVDC) cables that are laid from a special installation vessel at least 1.5 metres into the bottom of the North Sea. In mid-2019, the final cable section, measuring approx. 20 kilometres, will be installed in the Dutch/German Wadden Sea area. After a trial period, the complete cable connection will be in operation in the third quarter of 2019.

Subsea electricity cable

COBRAcable links Eemshaven (the Netherlands), through the German sector of the North Sea, to Endrup (Denmark). The connection has been constructed as a High-Voltage Direct Current (HVDC) cable, since the use of DC technology minimizes transmission losses over long distances and therefore virtually eliminates any loss of electricity.

Converter station

Two onshore converter stations – one in the Netherlands and one in Denmark – are needed to connect the cable to the Dutch and Danish HV grids. The converter stations will convert the electricity from direct current to alternating current and vice versa. The transformer will then ensure that the voltage of the converter (320 kV) is adjusted to the voltage of the Dutch grid (380 kV), so that the 700 megawatts that can be transmitted over the COBRA cable can be converted without any problems and connected to the high-voltage grids in Denmark (400 kV) and the Netherlands (380 kV).

'Green' cable

The COBRAcable will play a key role in the implementation of the Dutch and European sustainability objectives. The COBRAcable will ensures a better exchange of sustainably generated energy and a reduction of CO_2 emissions, and will promote the further integration of the European energy market and therefore have a dampening effect on electricity prices in the Netherlands and Europe. In addition, the COBRAcable will contribute to network stability in the Netherlands and Denmark, and the cable will more than pay for itself through the auctioning of transport capacity.

Other subsea electricity cables

The COBRAcable is not the first subsea electricity connection constructed by TenneT. In 2008 the TSO completed the NorNed cable between the Netherlands and Norway (capacity: 700 MW, length: 580 km). This was followed in 2011 by the BritNed cable between the Netherlands and the UK (capacity: 1,000 MW, length: 260 km). In addition to the new COBRAcable, TenneT is currently also working on the NordLink project, a 1,400 MW subsea cable link between Germany and Norway that is expected to be completed in 2020. ■

Cable
Capacity of 700 MW at approx. 320 kV (DC)
Total length: approx. 325 kilometres

Onshore:
- in the Netherlands: 1 kilometre of onshore cable
- In Denmark: 25 kilometres of onshore cable

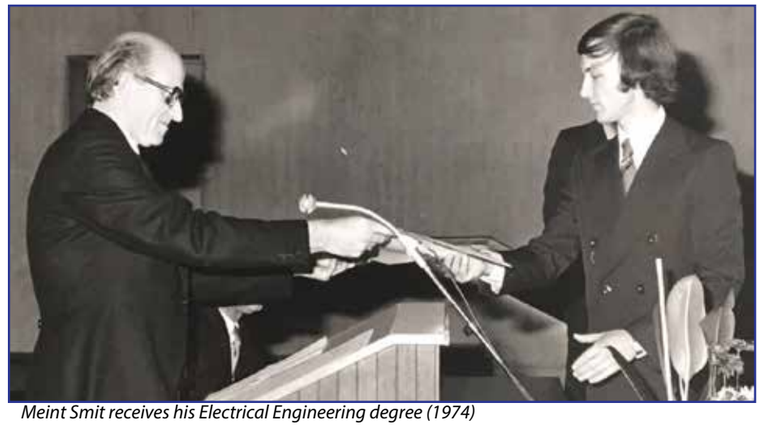
Offshore:
- 300 kilometres

40 years in Photonic Integration

By: Jan Vleeshouwers

On December 11th, Meint Smit officially marked the end of a career of forty years in Photonic Integration, with a low-profile symposium and reception in the Auditorium.

In a detailed presentation, Smit took his audience back to the origins of Photonic Integration (the design and fabrication of photonic circuits on chips) in the 1980s, which started with his work in Delft on photonic components. At that time, silicon was still his material, and aluminum-oxide provided the transparency needed to guide light. In the 1990s, the research began to include other materials, such as Gallium-Arsenide and Indium-Phosphide, which allowed his group to work on active components, such as optical amplifiers and lasers. This period also saw the first cooperation with Eindhoven, with the group of Joachim Wolter at the department of Applied Physics. The cooperation was extended to Twente, which led to COBRA, the Inter-university Top Research Institute on Communication Technology: Basic Research and Applications, within which the photonic integration activities have resided since.



Meint Smit receives his Electrical Engineering degree (1974)

COBRA applied for and received the NRC Photonics grant in 1999, a long term research budget of four million euro per year for a period of fifteen years. This structural funding has been very important for the development of Integrated Photonics. It enabled the building of a new cleanroom in Eindhoven, specialized in InP, and paved the way for the move of Smit's group from Delft to Eindhoven, in 2000. At that time, it caused quite some uproar, but the result was a concentration of research expertise in the photonics area, which was the basis for the developments in Photonic Integration we see today.

Meint smit during his farewell presentation (2018)

These developments include much of the elements electronic integrated circuits went through earlier. A generic integration approach was implemented on the InP-platform, which allowed various chip designs to be created in a single wafer run. Several companies have been founded since, to exploit the generic possibilities. The multi-project runs are coordinated by a special European platform, JePPIX, which is still coordinated by the Photonic Integration group (PhI).

Looking into the future, Smit foresees the gradual merging of the InP-based technology with the Si-platform. InP is still the material for active optical components, since making lasers in Si-technology is still next to impossible. But for other components, the Si-platform provides a level of fabrication expertise and control far outreaching InP. Combining the best of both platforms will be the way to go.

Meint Smit believes in this future and in lessons to be learned from the past. On these topics, he has written a small book which is about to be published. As a present from the PhI group, he received a very special multi-project wafer with artwork of the members of his group. ■

Women In Science Eindhoven

By: Ana Sobota

The WISE Network is a network of female scientific staff at TU/e. Its members are excited to share their experience, give each other support, and provide opportunities for personal and professional development in an academic setting. WISE celebrates twelve years of official existence this March.

Origins

The idea for the WISE Network was conceived in 2006. At the time, on average 10% of full professors and 16% of associate professors in the Netherlands were female, while TU/e had the lowest percentages in the country: 3% of female full professors and associate professors. TU/e started the Women in Science tenure track, having attracted five women in the first period. Simultaneously, personal development programmes were formed to support talented female assistant professors. The aim was not only to attract female scientific talent, but to also manage to keep them, and provide the framework necessary for their personal and professional growth.

Board members of the WISE network

With an expression of approval and support from the Rector, C.J. (Hans) van Duijn, in May 2006 a proposal was drawn up by Monique Jansen-Vullers and Mila Davids for establishing a network for female scientific staff at TU/e. The aims were to stimulate contact between the women in science at TU/e, organize activities for professional development aimed at women in science, offer opportunities for mentorship and to act as a sounding board for the CvB. In preparation for the creation of the women's network at TU/e, an event was held on 12th September 2006, entitled 'Women in Science: TU/e in balance'. Guest speakers on the topic of 'The creation of a new balance in our organization' included Hans van Duijn and the Dutch Minister of Social Affairs and Employment at the time, Aart Jan de Geus, who found the initiatives at TU/e, including the forming of a women's network, to be positive.

A similar conclusion was drawn from a survey that was done in the same period among the female scientific staff at TU/e. To the main question, 'Are the female scientists working at the TU/e interested in a women's network', the answer was convincingly affirmative (71%). 'It was very nice to encounter that a lot of our female colleagues were enthusiastic to join the network', says Davids. 'With many dedicated TU/e women it was not difficult to form the first board. During the past twelve years, the WISE Network has grown and has become even more active. When I look at the WISE network 2019, I am very pleased to see a lively network and many initiatives, thanks to energetic and dedicated board members'.

The first meeting of the Board of the Women's network at TU/e was held on January 10, 2007. The official letter of support from the CvB for the establishment of the women's network WISE came on March 29 2007, stating that the initiative is important and meaningful, inviting the chair of the Network for a yearly meeting and promising financial support. The WISE Network was officially launched in an opening ceremony on March 30, 2007, where the chair of the board of Utrecht University Yvonne van Rooij and Hans van Duijn had a debate about the merits of women in science.

The three women in the first meeting were Mila Davids, Monique Jansen and Marlies Oosterhuis. Soon after, the first Board of the WISE Network was formed. The Board has changed 36 members since then, striving to have at least one member from every department, ranging from PhD candidates to full professors. Only approximately 15% - 20% of all Board members were Dutch women.

Activities

WISE organizes several events per year. There are at least two workshops to provide training in personal and professional development, at least two very informal gatherings to provide opportunity to meet in a completely relaxed setting and one large event, typically in October. The yearly event, followed by a barbecue, is open to everybody, not only members of the WISE Network. The activities are always in English, as both the members and the guests come from different backgrounds.

The Childcare grant is the initiative that was started a few years ago. The idea is that going on a conference and having a small child at the same time is logistically challenging, not to mention expensive. The Network has, therefore, started an initiative where small grants of up to 500 EUR are available for WISE Network members with children up to 5 years of age who have to arrange childcare during a business trip.

Becoming a member of the WISE Network is easy – an online form is available on the webpage. The only prerequisite is that you are a member of the female scientific staff (PhD candidate or above) at TU/e. You will gain access to our events and childcare grant. For further information, you can go to our website and have a look at our portfolio.

At annual event 2018, the new chair of the WISE Board, Marion Matters (left), with the previous chair, Pascale Le Blanc(right)

Growing

After four years of being Chair of the Board of the WISE Network, Pascale LeBlanc passed this position on to Marion Matters (Professor at the Electrical Engineering department). 'Building and maintaining a strong university-wide network between women in science at TU Eindhoven and beyond is one of the key objectives of the WISE Network. It's via these informal contacts that important experiences can be exchanged and joint issues discussed. Also new research ideas pop up, especially interdisciplinary ones as WISE is bridging the faculties with ease', says Marion Matters. 'For 2019 we have chosen the theme 'Visibility', which gives us a specific focus for this year. Within this theme we started working on a stronger social media presence to reach more staff members at TU Eindhoven and to be more visible also outside TU/e, for example to our sister organizations at other universities. Another activity that we plan for 2019 is to encourage all staff members to invite more female speakers for symposia at TU Eindhoven. We also intend to reach out to our female bachelor and master students by exploring a student branch of WISE. We will continue to offer workshops related to professional development also this year. Supporting the careers of female staff members at TU/e is in the core of what the WISE Network stands for. The input we receive from the entire TU/e community on the topic of women in science will result in our advice to the College van Bestuur and the Diversity Committee'.

WISE is always on the lookout for new members of the Network, as well as new members of the Board and Affiliated members of the Board.

Becoming a Board member means that you will take on responsibility for a chosen aspect of the Board's work. There are plenty of choices, from taking care of the Twitter account or the WhatsApp group, to helping with the organization of activities, trying to find out what we can do together with similar networks at other universities or companies, etc. Alternatively, you might have your own idea for WISE.

Very recently the Board of the WISE Network has constituted the position of the Affiliate Board member. The Affiliate Board members can subscribe to the WISE Network mailing list, but they do not have access to the workshops organized for the WISE members, nor to the childcare grant. The aim of this position is to allow the cooperation between the WISE Network and non-members. For example, in the event that a WISE Board member wishes to conduct a project on behalf of WISE and could benefit from having additional expertise or support from outside the WISE Board, the WISE Board may decide to appoint other individuals as WISE Board Affiliates. This is a short-term, informal role, for e.g. six months or one year; Affiliates acquire no voting rights nor rights to attend board meetings. However, they may be listed on the WISE website as WISE Board Affiliates. Such Affiliates may be associated with TU/e or come from outside; they may be male or female. Being a WISE Board Affiliate does not make one a member of the WISE Network.

Becoming an Affiliated member of the Board requires a different scenario for every occurrence. If your ideas take you somewhere near the topic of WISE, don't be shy, contact us (wise-network@tue.nl). ■

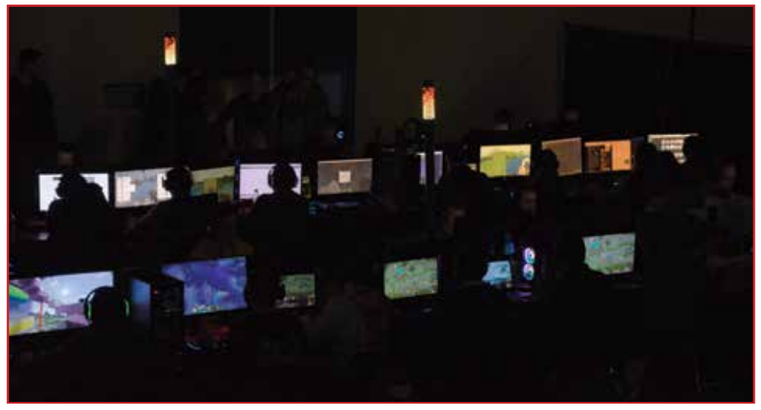
TU/e Technische Universiteit Eindhoven University of Technology

WISE-Network

TesLAN 2019 in detail

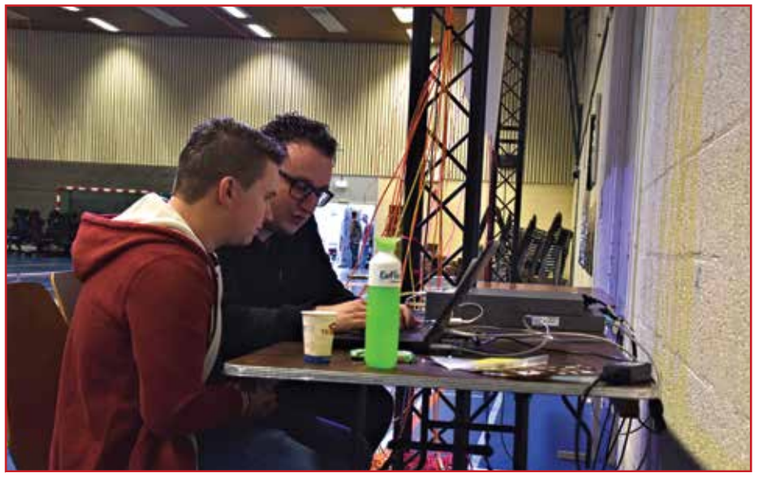
By: Max Winsemius

At the start of the year, one of Thor's biggest events and probably the first event of the year on the TU/e campus took place. Of course, we are talking about the TesLAN, a LAN party organized by Thor's LANCo committee of fourteen students; colleagues, but primarily friends. The event took place from January 3 to 5, but the preparations started almost a year before. With the evaluation of the previous edition of the TesLAN, we found out that there is a lot of potential to grow.



Even though this was the third TesLAN, this is the fifth year in which we organized a LAN party. The first was organized by our most experienced committee members, the Ivaldi-LAN. This name originates from the first-year committee of Thor, the Ivaldi. In the second year, most of those committee members organized the second LAN as the activity committee of Thor: the ACCI. This LAN was therefore named the ACCI-LAN. Both of these LAN parties were organized in the Gaslab, a nice place to grow from forty to eighty participants.

This growth continued, and we hoped to increase to 400 people this year. Hosting a LAN party of this size needs some well-thought requirements regarding competitions, prizes for those who win, information availability, internet connection, power usage, the looks of the event, server hosting for games, places for people to sit, et cetera. For this article, we take a deeper look into setting up networks, power usage and the looks of the event. For the latter, we look at the home-made gadgets specifically.

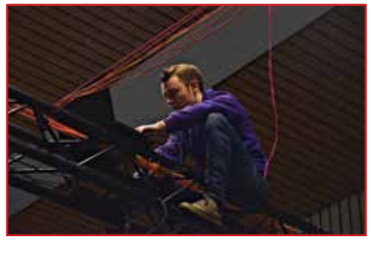


Light up the network

Last year, a basis was formed from which we could easily work further, as we had set up the correct configurations for the main router, core switch and leaf switches in a way that could be used again the year after. A 10Gb/s single-mode fiber connection was made available from the Laplace building, all the way up to the SSC network center, and from there, patched to the fiber that connects up to hall 2, into 40Gb/s-capable router. From this point, the connections were set up in a tree-like formation. The router was patched with a 10Gb/s connection into the core switch, which gave us the possibility to connect all the leaf switches with a 10Gb/s-enabled multi-mode fiber connection. On each table of twenty seats, we had a leaf switch with a surplus of about fifty 1Gb/s ethernet ports and four 10Gb/s-capable SFP+ slots. Our guests supplied their own ethernet cable, or if they really want to be able to get the best speeds available, they could supply their own transceivers and fibers as well.

The basic configuration of last year worked perfectly and was a good basis to start off this year, so this year's challenge was mainly focused on gathering statistics. Gathering statistics from network equipment from Juniper requires the usage of the Simple Network Management Protocol (SNMP). This protocol can be used to retrieve statistics from the router and switches, and it can also be used to set certain parameters.

To collect and store this data, you will need a database and a scraper that can fill it. After first setup, we noticed that with this basic

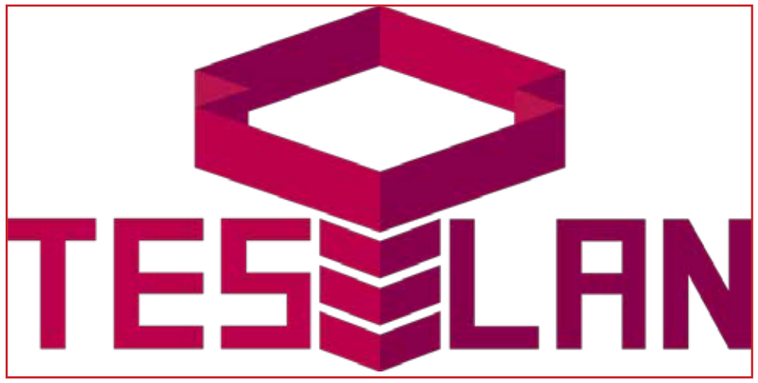


setup, we were only able to refresh every ten or fifteen seconds, due to the inherently slow nature of SNMP. After some optimizations and parallelization of the scraper, we were able to bring down the scrape duration from five seconds to around twenty milliseconds! We thought this would allow us to scrape at a higher frequency, only to find out the internal counters on Juniper equipment only refresh every five seconds, bummer. This nevertheless allowed us to reliably update our statistics dashboard every five seconds for our participants to check out.

There were of course also some setbacks. We had some problems with the 10Gb/s uplink connection to the TU/e, which we unfortunately weren't able to solve, even with the help of TU/e network staff. We want to improve the TesLAN and its network each year, and improving the reliability of the uplink will be one of our main focuses next year!

Turning on the power

Those switches obviously do not work on power over ethernet. On the LAN party there is a lot more infrastructure needed than just the network. With the Ivaldi-LAN, we only had a 63-A from a 380-V three-phase power source, which we converted down to twelve 16-A 230-V groups for the gamers and hackers to plug into. We estimated the average power usage on 350 W. Most desktops are rated higher, but not every pc runs at full potential, and some of our guests just take their laptop with them. To prevent the users from shorting their power strips, we announced that we would supply every person with a power socket in which they could plugin their personal power strips and other electronics. This would also cause the load to be nicely distributed amongst the groups.



As we grew to the bigger ACCI-LAN, we had to move to a bigger, better, and more capable location. The Student Sports Centre was the perfect solution for all these problems. As we grew even more with the first TesLAN and last TesLAN, several extra power supplies were installed at the SSC, which have sufficed us even up to this year. At this point, a total of thirty groups are available to us. Even though this sounds like a lot, we will outgrow even these facilities with the current growth pattern.

If we had been sold out this year, a total of 410 participants would have had to be facilitated. Several power sockets would be scavenged from the corners of the SSC (some even outside of the building) to supply with exactly enough groups, which would be a total of 45 groups.

As you can understand, powering the TesLAN is not easily done. Therefore, we are very happy there were no power failures on our side (someone's power strip went up in flames, though...). The final maximum total power we could have consumed this year would be a total of 110.4 kW.

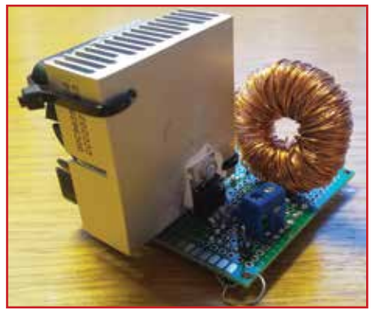
Getting our hands dirty

In anticipation of last year's TesLAN, Max and Mathijs stumbled upon the existence of EL-wire (electroluminescent wire) on Ali

Express. For the uninitiated: it is an arbitrarily long piece of wire that consists of an inner conductor coated with some phosphorous substance, encapsulated by a thin outer conductor, all wrapped in a colored transparent sleeve. The electrical engineers among us will have already guessed that it is therefore essentially a "Light Emitting Capacitor".

Amazed as we were with the cool, vibrant images kindly supplied by the seller, we ordered close to €100,- worth of it, including the necessary EL drivers. The plan was to build a giant TESLAN logo.

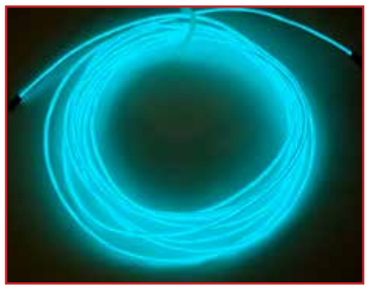
In all secrecy, we spent the Christmas break cutting up cardboard boxes that in a previous life had contained microwave ovens, and laced them up with EL-wire. We created eight segments (six letters and two logo parts) each with their own driver. Soldering



together some simple circuit boards using the beloved BS170 transistor allowed us to independently toggle drivers, enabling us to use an Arduino to program some cool animations for it. The total thing measured about six by three meters!

Upon mounting the rather complicated device to the wall in the sports hall, amazement struck us, followed by a quick realization that in order to really impress people, the brightness should have been quite a bit higher...

Flash forward to a year later: to improve on the geekiness of our LAN party, we decided that a new committee function had to be created: "Commissaris Beun", roughly translated as "Commissioner of Botch". The objective was to provide the event with more eye candy. Part of that was upgrading the existing (but ill-preserved) logo, and making it brighter.



A good rule of thumb when designing quality electronics is "if more current flows, things work better". That was exactly the philosophy followed when upgrading the logo. Since the EL-wire is a capacitor, obeying the formula

$$I=2\pi fUC$$

the obvious decision was to increase both free variables, the frequency f and the voltage U. The logo was stripped of its cheap standard drivers and equipped with eight new, shiny, handcrafted artisan units as shown in the image below .

Each of these units comprised a IRF1404 MOSFET with an actively cooled heatsink and a self-wound transformer coil (wound around cores sourced from old light dimmers) with thirty primary windings and a couple hundred secondary (no, this wasn't as fun as it sounds). Connecting the gate of the transistor to a microcontroller and harassing it with a square wave caused the EL-wire to glow significantly brighter!

Extensive theoretical models of the system have been developed, and numerical simulations (on the back of an envelope) predict an output driving voltage of about 400 V at 100 kHz. And all of this while consuming only 40 W per segment!

The last box that required ticking was to properly drive all eight units. By that time, the event was to be held tomorrow and other matters started to require attention, leaving the poor old logo to be transported to the premises without anything resembling an integration test being carried out. What happened next will not surprise you: it didn't work. This was due to various reasons, not all of which are known to the author.

During the event, shuffling some of the parts at least enabled the letter segments to work in constantly-on mode, averting total failure. Moral of the story: don't oversimplify things, always perform a system integration test, and don't throw sensitive electronics in a wet car trailer.

Gaming is over

After all, even with having a half-working TesLAN logo, an internet connection with some hiccups, and a malfunctioning power strip, everything actually gave us a real kick for organizing this event. Many of our guests commented that they experienced it as a well-organized event. Some complained about the internet, but others even came to us saying they had not experienced a LAN-party with such a fast internet connection available. These comments and experiences will definitely motivate us to do even better next year. There are already plans for an even better and more robust TesLAN logo. If you have any questions, please come by at the Thor Board room and check us out at the LAN party next year! ■

The impact of technology

By: Jan Vleeshouwers

Technology has a large impact on human society and on the world we inhabit. Our university recognizes that: the text below is from "Drivers of Change", the university strategy document for 2030.

Develop thought leadership is actually a quite surprising target. How can we truthfully work technological progress if we cannot substantiate our views on its impact? But the reality is different: many researchers still think it is not their role, and feel that impact is beyond their expertise.

In a recent article in NRC newspaper, brain researcher Robert Hampson is interviewed on his attempts to stimulate human memory through an implant, a technology with an undoubtedly high impact. When questioned if this technology should be available to people with a normal working memory, he says: "It is an interesting question if people should be able to choose for themselves, if they are equipped to make these kind of decisions for themselves at all. But ethics and society should discuss this, not me."

Many of us would have said something similar. I think there is some truth to that, in the sense that it is not the sole responsibility of the researcher or the engineer to have answers to all ethical and societal questions that application of a technology may have. History proves that the impact of technology is far too complicated to be able to predict in advance.

But that does not acquit us from leaving the impact question completely to "others", whomever they may be. Hiding behind a lack of expertise is a lame excuse. If you develop technology, you have to have some thoughts on how that might influence society, for better and for worse – for most certainly, both sides will be there. If not you, who else will provide the initial fact-based insights?

And if you have a career in technology, wouldn't it be strange if that would not lead to a more profound and general view of the impact of what you created or helped to create? I think that would be strange indeed. But most definitely, views on impact do not lead to discussions in our university community. Is that because we keep these views to ourselves, or is it because we don't have these views? I'm not sure what would be worse.

When I occasionally talk to people about technology impact, and ask them why there is no internal dispute about it, they generally admit that the topic is quite relevant and interesting, but that they are in lack of time. As my grandmother already told me, it is not about time, it is about priority (in Dutch that is a nicer play on words). So technology impact is not a priority. Don't think too easy of that: it is definitely not the message we want to bring across to society.

So what to do about it? I'm convinced the above strategy text will remain dead letter as long as there is no proper and vivid discussion among staff and students about the impact our work is having on society. But it seems most of us have different priorities. Should we accept that? If you think we shouldn't, let me know – and you can count me in. ■

3| ENHANCING THE IMPACT OF TECHNOLOGY

Enhance the impact of technology	Solutions that improve health, well-being and prosperity have to be sustainable. Engineers need to make responsible choices in the design, development and usability of technology. TU/e will involve societal stakeholders in technological research and stimulate engineers to have an open eye for the needs of society and industry.
Develop thought leadership	In the coming decade, TU/e will exercise thought leadership in our six research themes. We will proactively explore these fields in research and organize scientific meetings, write position papers, incorporate the fields into our life-long learning courses and develop a strong and recognizable voice both in scientific and public debate.
Encourage, support our scientists to contribute	In a broader sense, TU/e will take up its responsibility to engage with society and reflect on the ways in which technology influences our lives. In the public debate, TU/e will communicate contributions to societal challenges and discuss both the positive and problematic aspects of technological innovations. The scientific staff of TU/e has the right credentials to become thought leaders in this. We will encourage and support our scientists when they participate in the public debate about the topics of their expertise.

Train-surfing in Mauritania

By: Sander Verdiessen

After hours of trying, I am finally falling asleep, but then I taste some very dry substance in my mouth. I try to re-adjust my headscarf to prevent any of the fine dust from reaching my face. When I am almost satisfied with the result, I am suddenly thrown half a meter backwards after a sudden jerk on the carriage. I am now clearly awake and I remember exactly where I am and what I am doing. I am riding on top of an iron ore train through the Sahara in Mauritania.

Mauritania is a large sparsely populated country in West Africa. It consist of mostly desert areas and it is a place where two ethnicities meet. People of Arabian descent from the north of Africa and sub-Saharan people from the south live side by side. Despite its large size (almost 25 times greater than the Netherlands), it steadily ranks within the top 10 least visited countries in the world. It is for this reason that I started thinking about going to Mauritania. When I discovered I could ride on top of an iron ore train I made up my mind and booked a ticket to the capital of Nouakchott.

The iron ore train transports the ore gathered at the mines in Zouérat towards the port city of Nouadhibou. It is an important part of the country's economy, but it is an absolutely essential lifeline for the Saharan villages that are close to the tracks. The train company allows people to hop on the train and catch a ride for free while sitting in the iron ore. People transport everything on top of the train. Some go to the coast to buy fish and sell it in the desert and some even bring an entire flock of sheep along.

Before heading into the desert, I spent a few days in the capital of Nouakchott. Here I stayed with some friendly locals who showed me around the city. The city itself does not have much to offer for tourists, but I got to see a lot of authentic Mauritanian culture. I recommend everyone to try and stay with locals when travelling to learn to understand a culture in more detail.

It was time to head into the desert. I boarded a minivan packed with people heading to the city of Atar. The city is nicknamed the gateway to the Sahara, because it is the last major settlement before heading into the Sahara. Coincidentally there is a campsite run by two Dutch people. I stayed here for a night preparing for the adventure that lay ahead.

The next day I was going to ride the train. I decided I would jump on at the town of Choum, where I was told the train stops for a few minutes. Another crowded minivan dropped me off at the 'station', which looked more like a few brick walls. Despite the language barrier (my French and Arabic are not great) I managed to have a small conversation with some of the other people. They were going to buy fish at the coast and they were very interested in the rest of my travels in Mauritania.

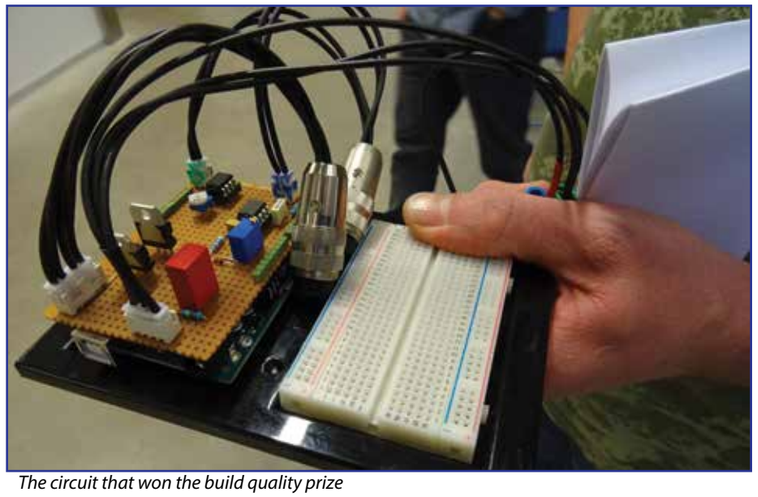
After waiting a few hours the train pulled up and this was already an amazing sight to behold. It seems as if the passing of carriages never ends. The train is around 2-3 km long, making it one of the longest in the world. When it finally pulls to a halt, I climb up the ladder to one of the carriages and start to get ready for the long journey. The train pulls away and slowly gathers up some speed. It is not long before all I can see is the train plowing through the vastness of the Sahara. I am overcome by a feeling of ecstasy and I lift up my arms to my side and just shout. What an amazing experience! As night falls I am greeted by the most beautiful night sky I have ever seen. This can only be experienced in very remote places far away from any human settlements. After 13 hours of incredible views, fighting with extremely fine dust and hardly any sleep, I arrive at Nouadhibou. It was a tough and long journey, but very much worth it! ■

Rock Your Baby demonstration

By: Jan Vleeshouwers

On Wednesday January 16th, nineteen first year's project groups demonstrated their attempts to soothe a crying baby, as did all of their predecessors of the past eight years. This year was special, since Michel van Eerd is taking over the lead of the project from Tjalling Tjalkens, who initiated the project in 2011.

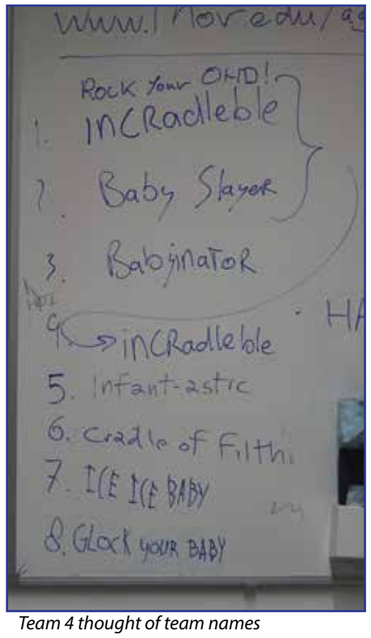
This year, most of the groups succeeded in their task, and the few which didn't, were very close. The prize for the quickest solution was won by group 18, for getting the baby to quiet down in 1:07 minutes. Team 4 was second, in 1:12 minutes and team team 1 was third, in 1:18 minutes. There was a special prize for team 19 for the build quality of their circuit. Team 4 also thought of a name for their team, and they thought of quite some options (see picture). Next year, the team numbers will probably not last until the end. ■



The circuit that won the build quality prize

Nineteen first year's project groups demonstrated their attempts to soothe a crying baby.

Michel van Eerd discussing the cause of the malfunction



Team 4 thought of team names

Group 13 and Tjalling Tjalkens anxiously watching the demonstration

My Life after EE

By: Christopher Geelen

My life after Electrical Engineering, or TU/e in general, was very dynamic. After my graduation in May 2014 I started out in the Research department of ViNotion, continuing in the field of my study. Four and a half years later, I find myself working in the world of front-end development and combine this with product management and business strategy. I learned so much by challenging myself with different responsibilities, and by participating in two start-up acceleration programs with training and coaching about business development.

Intro: Life during EE

I was asked to write a column for this new article series about life after the TU/e. But first let's give a bit of a background: I'm Christopher and I started Electrical Engineering in 2007. Why? Because it was challenging and I could experience a lot of different technologies. During my studies, I was also interested in developing my non-technical skills and therefore joined several committees, the Hajraa board, and pursued the Certificate for Entrepreneurship. For my Masters, I focused on the Research groups of Control Systems (CS) and Video Coding and Architectures (VCA, part of SPS). Because I was not sure whether to continue in industry or academics, I tried out both in my Masters (and would recommend everybody to do so, just to understand the difference).

The top of Annapurna Circuit, together with my fiancé Maartje.

My desk at ViNotion.

My internship was at the University of Canterbury in Christchurch, New Zealand. It was amazing! During my internship, I focused on applying Model Predictive Control to stabilize a model helicopter in the air, and afterwards had a month of hiking around. This started my addiction of hiking during holidays, even ending up with a fifteen-day Annapurna Circuit hike through the Himalayas, up to 5416 meter! During my internship, I contacted a company for my graduation project via my VCA professor, prof. de With.

This started my first encounter with ViNotion, a company focusing on advanced video processing applications that are able to automatically detect and classify traffic participants in real-time. During my graduation, I got more and more convinced to continue working in the industry, having a chance to combine both my technical and non-technical skills. I discussed the opportunities with my boss at ViNotion (Egbert Jaspers) and got the chance to learn and develop both. I continued this rhythm of discussing my career path and ambitions within ViNotion, hereby learning my strengths and goals by challenging myself in several functions and responsibilities.

Discussion with the COO and Head of Innovation of Kapsch. Copyright Kapsch TrafficCom AG.

Start of my working life

The start of my working life was amazing! Suddenly I had cash, I could contribute significantly to the company, and on top of all that, I could actually clear my head when I arrived at home, instead of continuously think about that one exam, report, or project that still remained to be done. I also enjoy the fact that I am still meeting with my friends from EE (also called the "2007"-group) every first Friday of the month in Het Walhalla or during our yearly WIDM-weekend. If I would mention one disadvantage, it's the fact that I can't slack off anymore (no more long sleep-ins on Friday morning!), but I guess you can't have it all!

At ViNotion, I continued my work in the R&D department, developing and improving the pedestrian detection algorithms in the product. Working in Python and C++, I used deep learning models to improve the accuracy. However, I noticed that I was not happy enough in this position; my work was taking a long time before ending up at the customer and made me feel unsatisfied. Therefore I transitioned to the team of product development, the team responsible for the hardware, up-time, and delivering the data to the API. I felt better knowing that my work was directly ending up at customer sites. However, once front-end development started up at ViNotion, I was hooked.

Front-end development originated at ViNotion during the development of our new product ViSense. The product needed a user interface, which customers could use to view statistics about their traffic movements, and configure the system at new festivals and crossroads. Although I had no previous experience, I decided to join the team and quickly learned about the world of JavaScript, HTML, CSS and front-end frameworks. The more I learned, the more I enjoyed this work! The beauty of front-end development for me is that it requires two different skills: both technical programming, and thinking about how the customer is using the product and wants the data to be accessible, without having any technical knowledge him or herself.

Illustration about the product of ViNotion. Copyright ViNotion.

Business management & strategy

As I mentioned, I also got the opportunity to develop my non-technical skills. This started out as a project leader of an innovation project for the Dutch Defense Department. The team consisted of four members of both ViNotion and the TU/e, and having support of Egbert, prof. De With and prof. Lukkien (Mathematics), I learned a lot in a small time. Currently, I'm the project leader of an international subsidy project (PS-CRIMSON) with one Canadian and four Dutch companies. Although the size of the project has increased considerably (budget-, scope- and timewise), the work you do as a project leader remains roughly the same. Although I don't see myself as a project leader in ten years from now, it is a good way to experience different aspects about running technical projects.

What really challenged me, was the opportunity ViNotion got in 2017. We got in touch with the company Kapsch TrafficCom AG, a multi-national corporation providing intelligent transportation systems for e.g. tolling and traffic control. They started a six-month start-up acceleration program to find and coach talented start-ups. It served two purposes: work together with the best start-ups to find possible co-creation on their products and coach the start-ups on aspects like sales, marketing, strategy and product development (start-ups with well-running business also benefit Kapsch in the long run).

We decided to give it a shot and join the 100+ other start-ups that subscribed to this program. I represented our company during the pitches and reached the finals, in which you had to pitch in front of 300 attendants and the jury of 10 executive board members (including their CEO). It was so challenging (and frightening!), but we nailed it! Together with Egbert, we ended up visiting Vienna four times for a week, and received a lot of coaching from different mentors. This really made our company stronger, even though we didn't end up having a partnership with Kapsch.

And, as if it was supposed to happen, in 2018 we got another opportunity to receive mentorship, by joining an acceleration program organized by the BOM (Brabantse Ondernemings Maatschappij). During an eight-week crash course, Egbert, Azem (sales) and I received personal coaching (no other start-ups during these sessions!) to improve our business and scale up significantly. We were required to analyze every tiny bit of the business processes within ViNotion, which was intense but worthwhile.

The team of ViNotion (2018). Copyright ViNotion.

Winners at Factory1 finals. Copyright Kapsch TrafficCom AG.

Today

Currently, I'm still working in the front-end development team, finalizing our revamped version of the ViSense web application. The sessions from the BOM helped Egbert and myself to set the strategy for the coming years, focusing on aligning the product development with the market and preparing to scale up the business. My challenge will be to manage the internal processes during this scale-up, so we are prepared for growth.

Looking back, I am happy that I tried out different functions and responsibilities. Starting out my working life, I did not know what type of business or function to pursue, but without trying, I would never have ended up learning as much as I did now. I really enjoy the current combination of front-end programming and business management, and even though I am unsure where I will end up, I am sure I will get there somehow. ■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1. TesLAN
2. Volundr 3D printing workshop
3, 4 & 13. ACCI weekend
5. Volundr soldering workshop
6. Lunch lecture Defensie
7. ACCI tv deco
8. ViNotion workshop
9. Lunch lecture Thales
10. Death star disco party
11. Candlemaking workshop
12. Woensdagploeg party

Human intelligence in biomedical diagnostics

By: Massimo Mischi

Biomedical diagnostics makes extensive use of imaging and monitoring technology. Accurate diagnostics are vital for better patient outcome and reduced healthcare costs as it facilitates timely and less invasive treatment. Biosignal analysis plays a major role in improving biomedical diagnostics. In contrast to recent trends, where artificial intelligence (AI) is employed as a black box tool for biosignal analysis, I would like to put human intelligence in the spotlight. Driven by clinical need, biosignal analysis techniques are developed that include understanding and accurate modeling of the full measurement chain: pathophysiological sources, sensing physics, and signal acquisition. Emerging AI tools can then contribute to enhance our understanding and improve our models. Based on these models, personalized diagnosis can be achieved, paving the way for patient-centered medicine.

Healthcare challenge

Today we are facing an epochal challenge because of the exploding demand and cost for the healthcare system caused by our greying society (30% over 65 by 2060 in Europe) and related increase in chronic and age-related diseases. This cannot be paralleled by an adequate increase in the financial and professional volume available for caregiving. In this situation, how can our society still guarantee high-quality care and assistance?

Biomedical diagnostics

I firmly believe that the answer lies in technological innovation aimed at transforming the healthcare continuum by reverting the order of the conventional pathways for caregiving. In particular, biomedical diagnostics plays a fundamental role in this process. Timely diagnosis is essential for effective prevention of disease progression and patient deterioration, and for limiting the disease to levels that can be treated either at home or by minimally-invasive intervention in the hospital.

Already the etymology of the term, diagnosis, suggests a strong link with the human drive to learn, which is central in our academic world. From ancient Greek, "dia" meaning "apart" and "gignoskein" meaning "to learn". As a whole, diagnosis means to discern and distinguish between different conditions, for instance between benign and malignant tissue. It is therefore the result of a learning process, referred to as diagnostics, which aims at understanding our (patho)physiology to detect and evaluate the onset and development of diseases.

Modeling the full measurement-chain

Physiology and pathophysiology, although already complex and not fully understood, represent only the first step of the measurement chain providing medical doctors with the inputs to make their diagnosis, such as biomedical signals and images. Correct interpretation of these inputs requires understanding of the full measurement chain (Figure 1), from the (patho)physiological sources, to the physics underlying the sensing process, up to the electronics conditioning the measured signals and/or forming the displayed images.

Based on our understanding of the full measurement chain, parametric mathematical models can be created that describe the measured (patho)physiological processes also accounting for the adopted measurement process. Modelling and parameter estimation lead to the generation of quantitative representations of the physiological parameters of interest. Quantitative rather than qualitative representations facilitate the clinical interpretation and diagnosis, enabling objective evaluations that are more accurate and reproducible.

Besides providing quantitative information, model-based analysis of biomedical signals also allows adjusting the model parameters to account for specific patient conditions. This is a fundamental step towards enabling patient-specific medicine, starting with a diagnosis that is personalized and tailored to specific conditions. Moreover, understanding and modelling the full measurement chain also permits improving the adopted measurement instrumentation and protocol.

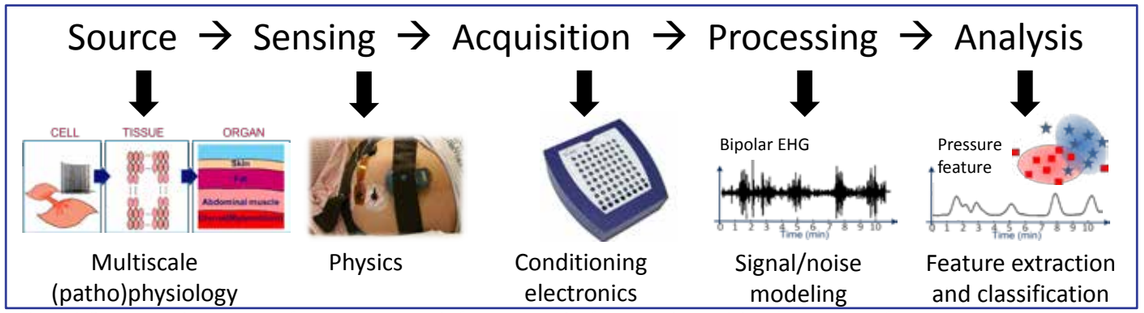


Figure 1: Representative example of measurement chain for the analysis of the electrical activity of the uterus, referred to as electrohysterogram (EHG) during pregnancy.

Improved diagnosis then results from a multidisciplinary effort aiming at optimizing all aspects in the measurement chain.

Probabilistic framework

Because of the trend towards multimodal, ambulatory acquisitions, the acquired signals may be severely affected by multiple, time-varying noise sources and artifacts, limiting the performance and applicability of deterministic signal analysis, and often resulting in misinterpretation and unreliable quantification. In order to cope with this problem, probabilistic frameworks can be developed where a-priori knowledge of the physiological sources and measurement chain is integrated with a probabilistic characterization of the parameter space, also including measurement uncertainty.

Within such a probabilistic framework, machine learning techniques have gained a prominent role for classification and diagnosis based on a number of features extracted from the acquired biomedical signals. In line with the model-based approach, the use of machine learning techniques can provide valuable support with the selection of the key features for interpreting and modeling the underlying physical and (patho)physiological processes.

Artificial intelligence

Somewhat different from the long-lasting efforts of many scientists to develop models describing the human (patho)physiology, today increasing attention is directed towards the use of AI, enabled by ever increasing computing power and the availability of large datasets for training convolutional neural networks. This is "deep learning", often used as a "black box" tool for making diagnostic choices based on complex models that are learned by the network but unknown to the humans. Although the results are often astonishing, they are not immediately generalizable and may be affected by unknown dependencies on the training dataset. Moreover, diagnostic failures cannot be readily explained.

The role of deep learning

Instead of seeking a "shortcut" to find easy solutions overcoming the complexity of biomedical diagnostics, AI can be considered as an opportunity to achieve better understanding of the (patho)physiological processes regulating our function and diseases. This can be achieved through latent-space and deep-layer visualization. So called "transparent" deep-learning approaches can be designed with the potential to propagate back and gain additional knowledge about the underlying physics and physiology.

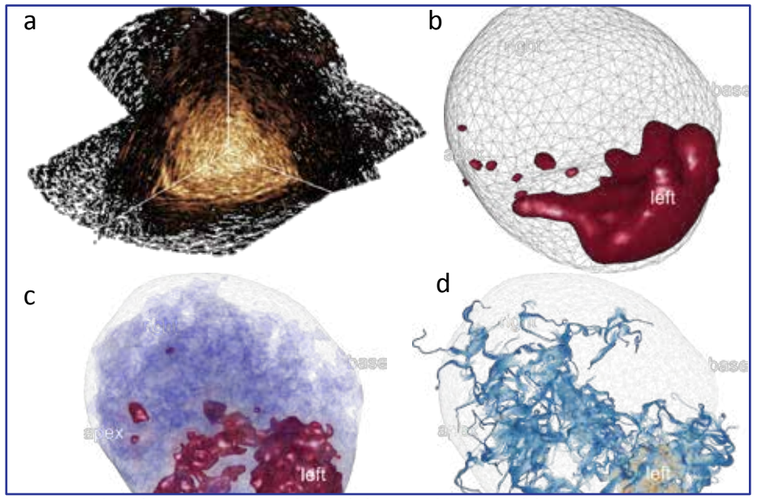


Figure 2: (a) 3D dynamic contrast-enhanced ultrasound imaging of the prostate with corresponding registered histology (b) and estimated dispersion (c) and tractographic (d) maps. All maps evidence the tumor area (red color) in agreement with the histological ground truth.

This way, the learning process can be used to enrich our knowledge, yielding reliable diagnostic solutions that are based on domain knowledge and improved understanding of the physics and physiology behind our biomedical measurements. In return, improved modeling can provide us with the ability to generate synthetic data that are good representations of the reality, enabling the use of deep learning also in domains where only limited data is available. This win-win situation may indeed result from reestablishing the value and role of human intelligence in biomedical diagnostics.

Application domains

Aiming at a large societal impact, we focus on those dysfunctions, diseases, and critical conditions that are widespread, and where timely and accurate diagnosis is crucial. Primary examples of this type are cardiovascular dysfunctions, cancer, and pregnancy, requiring different diagnostic solutions that are suitable for either high-end medical imaging (e.g., tissue and microvascular characterization) or unobtrusive, ambulatory monitoring (e.g., monitoring of pregnancy and atrial fibrillation).

Imaging

Noninvasive diagnostic imaging has a major impact on the healthcare continuum, enabling screening and minimally-invasive intervention through timely diagnosis. Being widely accessible, cost-effective, and perfectly suited to perioperative use, ultrasound imaging is an important research area that we address throughout the full measurement chain, by innovative interpretations of the measured signals as well as by innovative use of the acquisition technology. In this application area, quantification is an essential yet lacking option that we are constantly reinforcing through innovative research findings. Ultimately, accurate and reliable imaging is expected to become suitable for image-guided minimally-invasive intervention. Figure 2 shows an example of quantitative imaging of prostate-cancer angiogenesis using ultrasound contrast agents.

Monitoring

Multimodal unobtrusive measurements combining e.g. electrocardiography, photoplethysmography, and accelerometry, provide the inputs required for reliable model-based system identification through accurate estimation of physiological parameters with high diagnostic value. Figure 3 shows a setup for electrophysiological monitoring of pregnancy. Our research efforts are directed at providing technological solutions to offload the diagnostic burden in the hospital while enabling early and accurate prediction of patient deterioration at home. Acquisition redundancy can be exploited to boost the estimation robustness. Emerging acquisition technologies, based e.g. on large arrays of contactless sensors, are providing important opportunities for long-term monitoring.

Impact

Relevant solutions for biomedical diagnostics that can make an impact on our society, should be driven by clinical need, based on▶

domain knowledge, and suitable for implementation and clinical translation. This is facilitated by the establishment of a multidisciplinary research team combining academic, clinical, and industrial expertise. In particular, close collaboration and regular interaction with clinicians represents a unique opportunity to generate ideas and develop diagnostic solutions that tackle relevant problems, providing valuable support for improving clinical workflow and healthcare sustainability.

The value of a triangle

In fact, I believe that technological innovation making a societal impact builds on a fundamental triangle combining academia, clinic, and industry. In this way, we develop solutions that address both clinical needs and industrial interest. This is required for the clinical translation of our results, supported by industrial implementations that facilitate their clinical validation and uptake. To this end, building on a unique ecosystem made of flourishing companies and research-oriented, regional hospitals, the Eindhoven area is shaping towards a more structured and efficient approach to research and innovation. The most representative example is the e/MTIC (Eindhoven MedTech Innovation Center), a synergic research program involving TU/e, Philips, and hospitals in the Eindhoven region.

Spin-off ventures

Clinical translation and uptake indeed requires implementations that are suitable for clinical validation and use, and can be easily integrated in a clinical workflow. Larger companies often lack the flexibility required to support this process. More and more, small spin-off companies are formed that have the freedom and drive to push the implementation and promotion of new technology. This process creates unique opportunities for innovative technological solutions to make a real impact on society and healthcare.

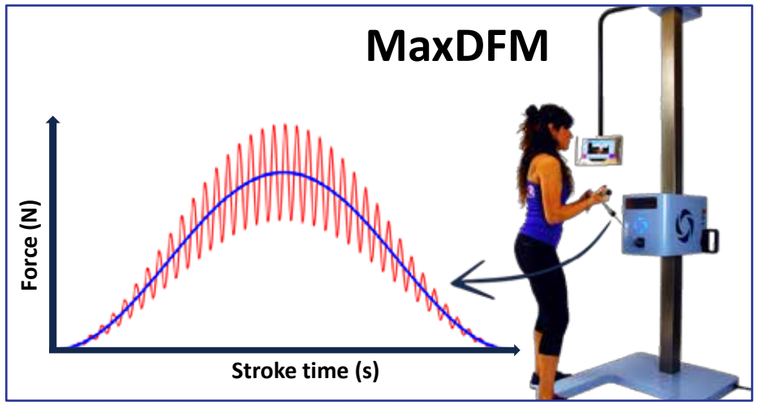


Figure 4: Maximized dynamic force modulation (MaxDFM) system for neuromuscular conditioning applying a dynamic load to the muscles consisting of a slow-varying force modulated at higher frequency.

I have had the possibility to lay the basis for two spin-off companies in the area of neuromuscular rehabilitation (HiPerMotion, Figure 4) and prostate-cancer diagnosis by ultrasound (CUDI, Figure 2). This experience provides a unique opportunity to enrich our view on research with different perspectives, accounting also for societal need, market size, and route-to-market strategies based on proper knowledge of the main stakeholders. To make real impact, our research should already account, in its early phase, for the full socio-economic context, moving towards technological solutions that are suitable to raise industrial and clinical attention.

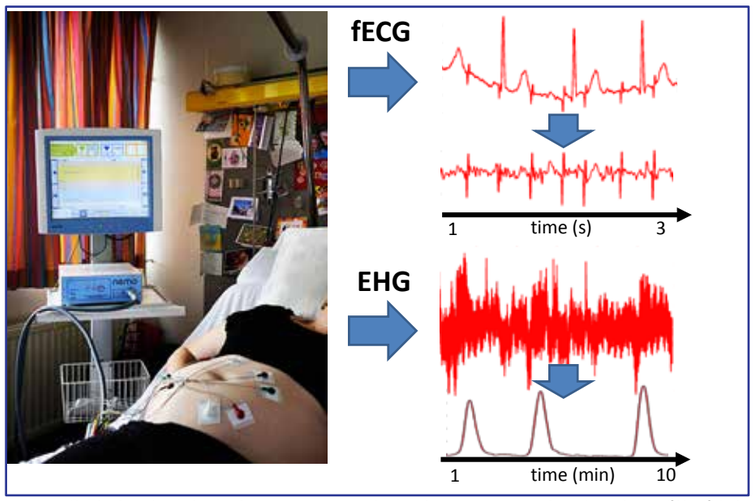


Figure 3: Electrophysiological pregnancy monitoring by measurement and analysis of the fetal electrocardiogram (fECG) and the electrohysterogram (EHG), reflecting the activity of the fetal heart and the uterus, respectively. After model-based de-noising, the fetal heart rate (above) and the intrauterine pressure (below) are estimated.

Conclusion

The term "human" has multiple connotations. The drive behind our research efforts and achievements is human, based on our natural inclination towards curiosity. AI intelligence provides extraordinary means to learn from the large amount of data that we now have available, providing an additional contribution to human knowledge and understanding. In fact, I firmly believe that effective and reliable healthcare improvements can only be achieved through understanding human (patho)physiology and the full measurement chain employed to acquire biomedical signals and data.

Restoring human rather than machine learning to the spotlight is especially valuable for our students. Curiosity and creativity is the basis of innovation and are prominent when we are young. That is why our students and young researchers have immense potential to be innovators and to face the modern challenges in healthcare. They should stay open, curious, and creative, like a child. After all, I believe that inventive ideas occur in that very moment when, with all our knowledge, we are children again. ■

Automotive Talk

with Robin en Menno

At parties, we get asked all the time: "What do you study?" Our answer nowadays is something like: "I study Electrical Engineering and specialize in mobility". However, whenever we say this, we are not satisfied with the answer. Automotive Technology is much more than this. So, what is "automotive technology" then? We don't know. We are not linguists. What we can tell you, is how we experience our study, and what areas we spend our time on. During the first year of Automotive Technology, we have learned a lot of basic things, just like the "real" Electrical Engineering students. The major difference is, they learn the basics of circuit design in the first year and we learn the basics of (vehicle) dynamics. The EE students use their knowledge to build circuits with their projects, while we learn how to model an (albeit easy) vehicle.

Programming is a major part of both Electrical Engineering and Automotive Technology. It always surprises me that many people do not expect this. We built the computer, so it is better when we have the knowledge on how to use it too. Also, looking forward, the price of computational power is dropping steadily. Microcontrollers are dirt cheap. The best electrical engineering solution is the cheapest but gets the job done. A line of code often costs less than hardware solutions and is, on some occasions, becoming the favorite solution. This is visible in the automotive industry, cars changed from just a combustion engine on a chassis to the car of today that can be seen as an iPad on wheels. A mechanical system that changed into a complex system that contains mechanics and electronics. Studying Automotive Technology really means studying these systems. The knowledge we obtain by doing so can also be applied to any other dynamical system. This also explains why there are many Automotive Technology students who are not even passionate about cars. They are just broadly interested in many electrical and mechanical phenomena. What we learn can be applied to a logistics robot, a potato sorting machine or whatever other system you can come up with.

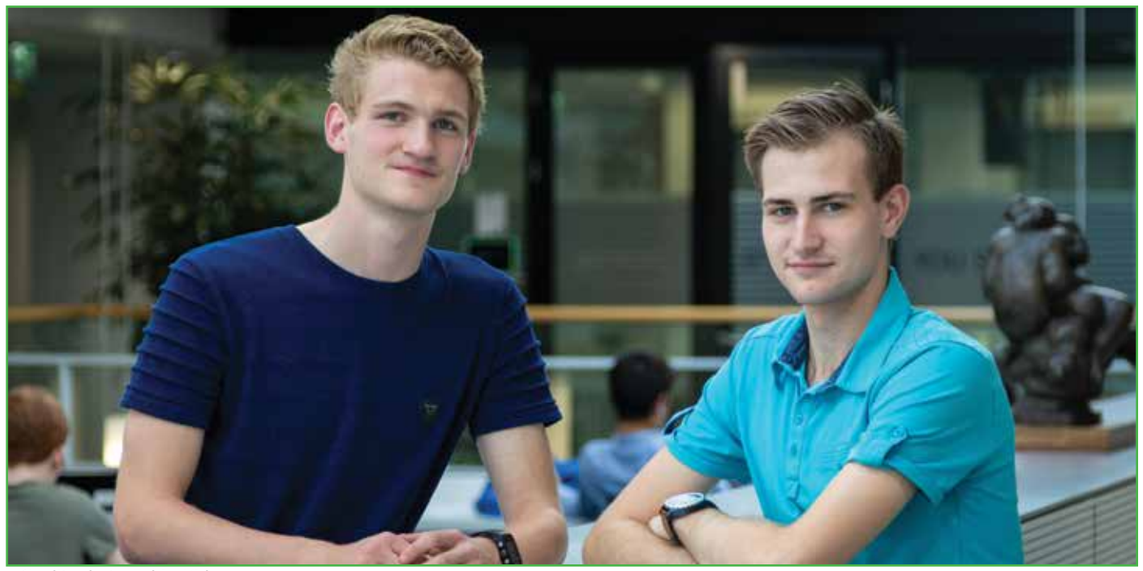
We think that the need of these multidisciplinary system engineers is rising with the increasing complexity of the systems. All disciplines used to be (somewhat) separated. Volkswagen hired mechanical engineers. Cell phones were made by electrical engineers. The insides of the systems were completely different. But now everything is interconnected. A Tesla car and a smartphone look very different from the outside, but when comparing the inside there are many similarities. Both are using microcontrollers, data analytics and wireless connections.

We think multidisciplinary is a keyword in describing Automotive Technology. You cannot put us into one box.

Also, there is the elective space in which we are free to choose whatever we want. I think this a nice opportunity, we see people diving deeper into programming or electronics, or broadening their horizon by taking economics and entrepreneurship courses.

So if we could answer on birthday parties with: "I study Automotive Technology at the University of Technology in Eindhoven, where I spend a lot of my time on electronic systems, including circuit design, electromagnetics, signals and control, and programming. Another major part of my studies is vehicle dynamics. But I also have a basis in math and physics", we would. But unfortunately that is a really long summary for parties.

The follow up question I sometimes get is: "So Menno, what do you do in your spare time?" I say: "We have a project: building an electric vehicle (with beer tap trailer)." ■



Credits photo: FabicoVideo

3D Microwave Camera

By: Debashis Dhar

I am a PhD candidate (fourth year) in the Integrated Circuits (IC) group (previously MsM) of our Electrical Engineering department. I have been working in the NWO-funded project – MUSIC (MUltiple-input multiple-output Silicon-based mm-wave Integrated Circuit radar). My main goal in the project is to design a PLL-based frequency synthesizer for phased-array radars. Overall, my interests are in the broad area of RF/Analog/Mixed-Signal circuits and systems such as PLL, DLL, wireless/wireline transceivers, and data converters. Apart from designing RF/Analog systems, I also enjoy designing and analyzing fundamental analog blocks like operational amplifiers, voltage regulators and comparators.

Here, I would like to talk about the MUSIC project I am working in. The aim of the project is to develop a complete 3D Microwave camera, mainly targeting automotive safety applications. Before a discussion on the 3D camera, it is of interest to know the necessity of such a system. Imaging in harsh environments such as heavy rain, fog or snowfall is crucial for automotive safety. Conventional camera or LIDAR (light detection and ranging) technology fails to produce clear images in harsh environments, making it really difficult to drive safely. But, microwave signals can travel through these harsh environments and detect objects reliably. Motivated by this extremely useful feature, the aim of our project is to build a '3D Microwave Camera' system, based on multiple 60 GHz single-chip FMCW (frequency modulated continuous wave) radars. The radars are arranged like a phased-array, in this particular case, a non-regular one. The radars in the array works synchronously to produce images and distances of objects. The camera is expected to detect objects at a distance of 50 meters.

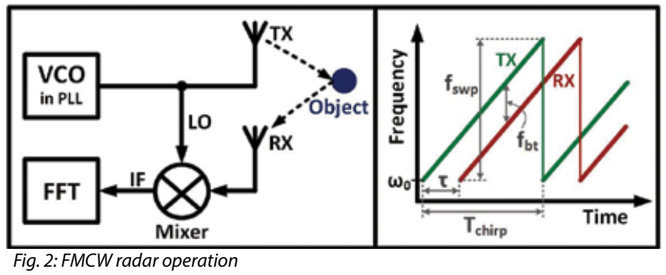


Fig. 2: FMCW radar operation

Applications

The proposed 3D camera has all the potential to become a very important part of autonomous driving. Currently, LIDAR is being used to create 3D images for cars. But, it is expensive and performs poorly in harsh conditions. The 3D microwave camera can overcome these issues to enhance automotive safety. One of the other advantages of the 3D microwave camera is its small size. Due to this feature, it can be used as a portable metal detector in airports or public events to detect concealed weapons. Furthermore, it can help detect anomalous human behaviors in large events, which will facilitate quick response in urgent situations. In healthcare sector, the camera can be used as a 'microwave eye' to create 3D overview for blind people.

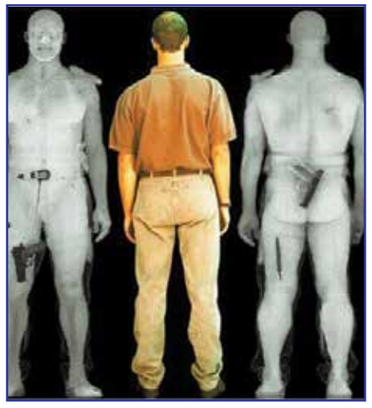


Fig. 1: left, Imaging for automotive; right, Metal detector for security market

Operation of the FMCW Radar

Similar to other types of radars, FMCW radar transmitter sends out a signal and calculates the object distance from the received signal. In case of the FMCW radar, the transmitted signal has a frequency that changes continuously with time from a low value (57 GHz) to a high value (64 GHz). The signal with frequency ramp is called a 'chirp.' The phase-locked loop (PLL) in the FMCW radar generates the chirp. After the chirp is transmitted, if there is an object in the path, the receiver receives a time-shifted chirp from the reflection. The transmitted and received chirps are mixed in the receiver. This creates a small frequency difference called 'beat frequency.' The distance of the object is calculated from the beat frequency. The operation is pictorially shown in Fig. 2.

The Problem of Synchronization

When FMCW radars are used in phased array configuration, their PLLs must be synchronized, meaning that the starting point of each PLL output signal must be known. The lack of synchronization would result in beam direction change (i.e. radiated energy not traveling in the right direction) and increase in side-lobe levels. Side-lobes can be considered as noise. Increase in the side-lobe level is particularly problematic because it leads to false object detection (i.e. radar detects an object even if there is none). The synchronization problem arises from the random phase mismatches between PLL output signals in different FMCW radar chips. Therefore, the phase mismatches between PLL signals must be minimized to successfully develop the 3D Microwave Camera. At this point, the major question is what, in PLL, causes these random phase mismatches.

What Causes Phase Mismatch between PLLs

PLL is a negative feedback system that aligns the phase of the output signal with that of input signal. In this process, it generates a very accurate output frequency. In the FMCW radar, a charge-pump PLL (CPPLL) is used as a frequency synthesizer. It produces an output signal whose frequency is the multiple of a reference frequency provided by an external crystal oscillator. The crystal oscillator is a highly pure signal source, but its output frequency is low. In our case, crystal oscillator frequency is 25 or 50 MHz. Other components of the CPPLL are a phase-frequency detector (PFD), a charge pump (CP), a loop filter (LF), a voltage-controlled oscillator (VCO) and a divider. The divider is placed in the feedback path of the PLL. The output frequency of the PLL is determined by the divide value (N) and the reference frequency. A block diagram of the CPPLL is shown in Fig. 3.

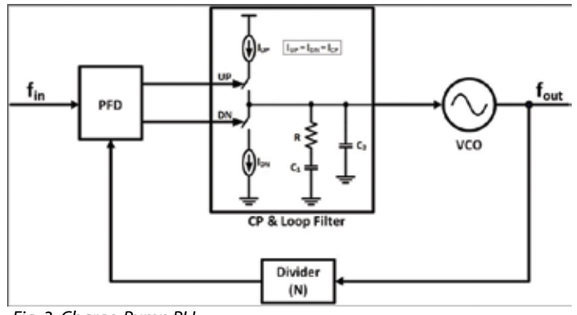


Fig. 3: Charge-Pump PLL

The PLLs in multiple FMCW radar chips are fed from the same crystal oscillator (25 or 50 MHz) to generate 30 GHz signals. The 30 GHz signals are frequency-doubled to produce 60 GHz signals. As the PLLs are sourced from the same crystal oscillator, their input signals are synchronized i.e. the phase shift is 0°. PLL output signals are also expected to be synchronized (i.e. 0° phase shift). This is only possible if the dividers on multiple chips have the same latency or delay. However, in reality, the divider delay can vary from chip to chip due to manufacturing imperfections. During chip fabrication process, the characteristics of the transistor devices that make up the divider, vary from chip to chip, which results in different delays for different dividers. This leads to synchronization failure between radar nodes, which can cause false object detection. To synchronize PLL output signals, the delay variation of dividers must be minimized. The proposed synchronization technique is described below.

Achieving Synchronization between PLLs

The synchronization between PLLs on multiple chips can be achieved by making the divider delays constant. A delay-locked loop (DLL) can be used to ensure that all the dividers on different chips have the same delay or latency. Essentially, DLL works as an auto-calibration system that tracks and cancels out the variations in dividers on different chips to ensure constant delay. A chip based on the proposed synchronization technique will be fabricated soon to validate the idea.

Demonstrator Board and Future Products

As shown in Fig. 4, a demonstrator board has been built using a previous version of FMCW radars to evaluate the performance of a test MIMO array. It has successfully detected objects with a resolution of 7 cm. In future, new version of FMCW radars will be designed using the proposed synchronization technique. Based on the new version of FMCW radar, a number of products will be launched for automotive, security and healthcare markets. ■

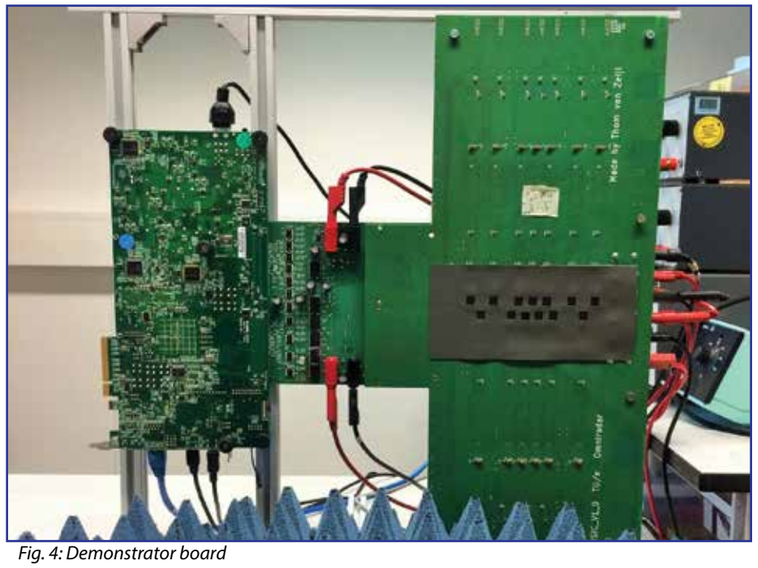


Fig. 4: Demonstrator board

Internship abroad

By: Guus Engels

For almost four months I went to Vicomtech, an applied research centre company in San Sebastian, in the northern part of Spain. I lived in the middle of the Basque country and worked on an object detection algorithm for automotive applications.

Vicomtech specializes in computer vision, language technologies, data analytics, and advanced interaction technologies. I joined the department of intelligent transport systems where my focus was on object detection on LiDAR data. A LiDAR is a laser sensor that sends out a light signal which reflects on an object in its surroundings, which then is intercepted by the sensor. From the time it takes for the light to travel, an estimation of the distance to this point can be made. The sensor is able to generate hundreds thousands of points which give a good 3D approximation of the environment. Based on this data the goal was to design a network that is able to detect different objects in the street, such as pedestrians, cars, and cyclists. I learned a lot of things related to programming, neural networks and in general working in a different environment than the university. I made some progress on several challenges but there is still a lot of work to do. Luckily I will be able to do my graduation project on the same subject and can carry on with the research.

San Sebastian

Vicomtech is located in San Sebastian, a city in the north of Spain. It is a very popular tourist destination and especially for Dutch people, it might be interesting. This is because it is considered to be a bike-friendly city with a total length of thirty km of cycling lane. Cycling is a great way to explore the city, but be aware: there are some challenges to overcome. Bicycle lanes can stop out of the blue or continue on the other side of the road. It is very useful to have a city map of all the cycling lanes to avoid confusion and excessive use of the brakes. Furthermore, there is a concept in San Sebastian which I was not so familiar with in the Netherlands, and is called a slope. At first I planned to commute by bike, since according to Google maps it was only a 17 minute ride, so not too bad.

Top view of the San Sebastian coast line

What Google maps failed to mention was that this information was probably based on the conditioning of 2004 Lance Armstrong. After climbing several category one mountains and using Google maps to figure out where the nearest cycling lane was, I finally arrived at the company. After a ten minute recovery, I came to the conclusion that investing in a card for public transport might not be the worst idea.

Basque region

San Sebastian is located in the Basque region, home of the Basques, which covers the north-central part of Spain and the south-western part of France. It has a very distinctive culture, including its own language, traditions, cuisine, sports, lots of rain, etc. The name of the city in Basque is Donosti and is used more often in the Basque country. What belongs to the Basque country and what does not, is a bit controversial. There is the Basque autonomous community where San Sebastian and also Bilbao lie. It has its own government, and the Basque language is very prominent in this region, although Spanish is still the main language. The greater Basque region also includes the French part of Basque country and Navarre, an adjacent region with Pamplona as its capital. Its history is very intertwined with the autonomous region where fewer people speak the language. I have talked to several people about what they think belongs to the Basque region, and got very different answers. Some based their arguments on the cultural similarities and history, while others were more focussed on the language aspect. I am not sure what my own conclusion is, so I will just use a cliché in the scientific community: "further research is needed".

Language

The most important part of the Basque culture is its language, Euskara, which is unlike any other language in Europe. It does not resemble any Roman or Germanic language, and its origin is mostly unknown. In the time of Franco, it was not allowed to teach the Basque language, but after his regime ended, it became much more prominent again. Children often go to schools where Euskara is the main language, and are brought up to be bilingual. All signs, warnings, and general text in public space are first written in Euskara, and beneath that there is the Spanish translation. Even though the language is very prominent, Spanish is the first language and spoken by everybody. Euskara uses the same alphabet as most European languages, but without the C, Q, V, W and Y. The letters used might be similar, but written Euskara is very distinctive from any other European language. What catches your eye immediately, is the heavy use of letters such as 'x' and 'z' compared to other European languages. It also has strange combinations of consonants like 'tx', 'rtx' and 'zk'. I am told that the pronunciation is fairly similar to Spanish. I did not come to this conclusion by myself, since I speak neither language particularly well, so let's just assume it does sound similar to Spanish. To give a short crash course in Euskara here are the most important words, which are also the only words I know; "kaixo" = hello, "agur" = bye, "eskerrik asko" = thank you, and "Bi garagardoak, mesedez" = two beers, please. With this extensive knowledge of the language, I was able to survive for four months, so I think this is enough preparation if you are planning on going on a holiday to the Basque region.

Culinary

Beside the language, an important part of the Basque culture is the cuisine. The restaurants in the city have a combined eighteen Michelin stars while having a population smaller than Eindhoven. The density of Michelin stars is one of the highest in the world. There are so many small bars and restaurants with amazing food. The most common dish is a "pintxo". It is a small snack that typically consist of a slice of bread with on top a mixture of ingredients. A toothpick is used to hold everything in place. Pintxos are relatively similar to the more well-known Spanish dish called tapas. I would advise against making this comparison when there are Basque people around, since this is the number one Basque culinary sin. Once you have learned the difference between a pintxo and tapas, you can look more into the Basque gastronomy. San Sebastian is where the first gastronomy society originates from. These societies are very influential for the Basque cuisine and important for several reasons. A society is a place for members to meet, socialize, and cook. Every week, different members cook and try to impress the other members with their dish. Due to the slightly competitive atmosphere, there is a lot of experimentation with new ingredients and recipes that enrich the Basque cuisine. The most prestigious societies have a waiting list of many years. It is also possible to learn in a more formal way about Basque cuisine by going to culinary school. The Basque culinary centre boasts the first academic degree in Gastronomy. Some of the culinary students were staying at my residence, where they had to practice preparing dishes. They asked me to taste their dishes a couple of times (poor me), which tasted awesome. Among all the culinary brilliance, there is one "restaurant" which strikes the fear in the hearts of every Donostiarra, namely, the McDonald's. There is only one McDonald's

Driving simulator where the drivers physical state is monitored

Pelota court in the middle of San Sebastian with a famous gastronomy society above it

in the entire city, but it has a very prominent location in the middle of the city centre. I can only imagine the grieving and depressed atmosphere in the city when it first opened fifteen years ago.

Sports

Sports are also very important in the Basque country. Many traditional sports, such as wood chopping, rowing, stone lifting, and Pelota, are still being played vividly. The latter one has similarities to squash, but instead of using a racket, the palm of the hand is used to hit a ball up against a wall. There are some different variations with one, two, or even three walls. The most popular one is the one with two walls. In the city centre there is one which seemed to be always in use, even in December. Often it is used by kids that are not older than ten years old, but they are still able to hit the ball extremely hard and accurate. Although the traditional sports are important in the Basque culture, the most popular sport is soccer, and especially the rivalry between Athletic Bilbao and San Sebastian (Real Sociedad) is intense. While overall the city of San Sebastian is considered to be much more beautiful because of the architecture, beaches, and the nature that is embedded in the city centre, one aspect was a bit less pretty during my stay. Bilbao got an amazing new soccer stadium in 2013, while the one of Real Sociedad at the time of writing has a massive hole in the side of the stadium. Many students at the residence were originally from Bilbao and had a lot of fun with the situation. I saw many of them taking a picture of the everyday increasing pile of rubble to send to their friends back in Bilbao.

Looking back

My experience in the city and the Basque country has been awesome. I liked the city and my internship a lot and I met great people during my stay. An internship abroad is a great experience since it will really immerse you into a different lifestyle. I believe this experience will help me a lot further in life, both academically and personally. I will certainly revisit San Sebastian and hope that this story has inspired you all to visit it as well, and go for an internship abroad. ■

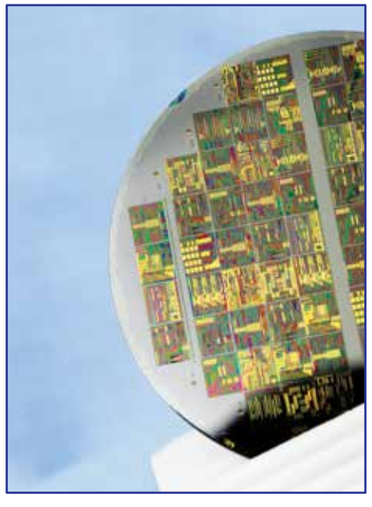
Integrated Photonics: Basis for the next societal revolution

By: Ton Backx

The past sixty years, microelectronics have revolutionized the world in many ways, e.g., by enabling major leaps in labor productivity by automation, large-bandwidth communication accessible for nearly every individual, significant progress in health care technologies, major improvements in mobility, prosperity for a rapidly growing number of people, just to mention a few. Now, we are at the edge of a new technology that is going to conquer the world with at least a similar impact potential as microelectronics have made the past decades: Integrated Photonics.

Similar to micro-electronics circuits, which are complex electronic circuits integrated on a chip, photonic integrated circuits are complex photonic systems integrated on a chip. Photons are the basic carriers of information for this type of semiconductor material based circuits. As photons don't carry electric charge, they don't lose energy while moving. This property enables major improvement in energy efficiency of photonic integrated circuits compared to micro-electronic circuits. In addition, photons don't have mass. As a consequence, they always travel with the speed of light. These properties potentially make photonic integrated circuits enablers of very large bandwidth and extremely energy-efficient processing of information. An additional property of photons is that they can excite molecular or atomic vibrations and that they can interact with electrons to bring them to metastable higher-level quantum states. Furthermore, the electrons may spontaneously fall back to their stable ground level state by emitting a photon with energy $E1=h\nu$, that exactly equals the energy difference between excited state and ground state of the electron. This fallback may also be stimulated by a photon with exactly this same energy E1 resulting in two coherent (same frequency, same phase and same polarization) photons. These properties of photons open a whole new world of applications, which can contribute to solve the major societal challenges we are facing today.

Photonic integrated circuits will be the basis for next generations of datacenters. They will ultimately support further exponential growth (annual growth rate 1.3-2.0) of data traffic by enabling orders of magnitude



larger bandwidth and handling of data at orders of magnitude lower energy demand per bit handled.

Photonic integrated circuits will also enable new sensor system developments with a wide range of applications, e.g. for low-cost next generation healthcare, for autonomous driving systems, for high-performance manufacturing, for building low-cost, high-performance and reliable security systems, for high-performance recycling of materials, for air, water and food quality monitoring and control, and many more.

Eindhoven University has a strong history in research related to the development of photonic integrated circuits and systems. In 1998 the groups working together in COBRA –group of prof. Joachim Wolter (now Andrea Fiore), group of prof. Djan Khoe (now Ton Koonen) and group of prof. Meint Smit (now Kevin Williams) – received a Top Research School grant of four million euro per year for a period of ten years that in 2007 was extended with five years in addition until 2013. This grant was received for the good scientific reputation the collaborating groups had built up already at that time. The additional five years of basic funding were received while the groups further improved their scientific performance and had become world-leading at that time. With this funding, the groups continued strengthening their reputation in research. They have grown significantly over these years and have been able to attract a lot of additional funding and many good young people for doing the research and education in the field.

In 2013, when the Top Research School funding program ended, the collaborating groups received new basic funding from NWO ("Zwaartekracht") for a period of ten years again, and several (advanced) ERC grants. The team of collaborating groups was extended with two additional groups – group of Erwin Kessels and group of Bert Koopmans – to also cover materials processing research and spintronic research. After splitting off the group of Erik Bakkers from Andrea Fiore's group, this group as well became part of the team for doing nanowire-related materials research. In 2016, it was important to further improve visibility of the integrated photonic circuits and systems activities. The Institute for Photonic Integration (IPI) was established for this purpose. IPI and the PhotonDelta organization, which was setup around the university, were instrumental in further organizing the Dutch national activities in Integrated Photonics. In PhotonDelta, all parties with relevant activities in integrated photonic circuits and systems development in the Netherlands were brought together and developed the National Plan on Integrated Photonics. This plan was approved in 2018 as a Public Private Partnership (PPP), as part of the Topsector High Tech Systems and Materials. The PPP received 240 million euro in total for further development of the Dutch economic ecosystem active in the field of Integrated Photonics in the coming eight years. After these eight years, this ecosystem has to be self-sustaining. The allocation of the funds available will be managed by the foundation PhotonDelta. This foundation started its activities January 1st, 2019. The funds will be invested in four domains called "Pillars":

Pillar 1: Establish World Class Platform (indication of the budget: 20-25 million euro)

The activities in this pillar concentrate on the realization of high-performance manufacturing of generic technology-based prototypes and world-class products by companies specialized in integrated photonics

Pillar 2: Develop Next Generation Platforms (indication of the budget: 160-170 million euro)

This pillar covers the applied research and development activities related to the execution of application-driven, ambitious development projects. The activities financed include applied R&D and development of required technology platforms.

Pillar 3: Create Shared Infrastructure (PITC & CITC) (indication of the budget: 40-50 million euro)

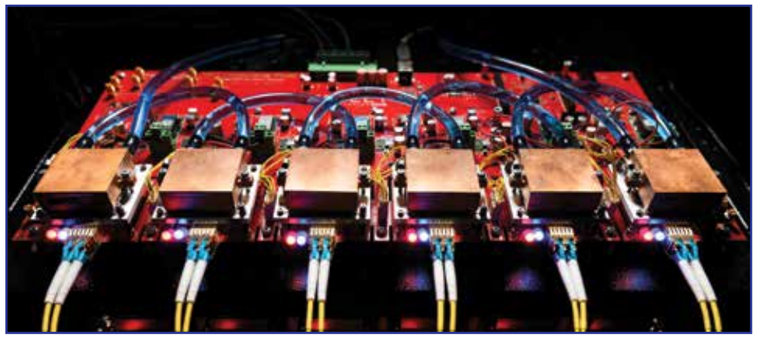
Several applied R&D activities require similar infrastructure for developing manufacturing equipment, testing and testing equipment development, assembly of photonic integrated circuits and systems, etc. This infrastructure can be shared to a large extent. The development of shared infrastructure driven by needs stemming from photonic integrated circuits and systems roadmaps is the core of pillar 3. The shared infrastructure is enabling prototyping and development of manufacturing processes.

Pillar 4: Expand Ecosystem (indication of the budget: 10-15 million euro)

It is strongly desired to make connections both within and outside the sector to stimulate rapid growth of the ecosystem. This also includes financial support of integrated photonic circuits and systems applications in application labs and incubators. Pillar 4 is focusing on driving this type of investments.

With these activities, PhotonDelta together with its European partners wants to build up a global leading economic position in this field.

PhotonDelta has furthermore initiated, together with its US-based counterpart AIM Photonics, the global "Integrated Photonic Systems Roadmap – International" (IPSR-I) development. The first IPSR-I document will be released in March 2019. The structure of working groups and four physical meetings per year has been established for this long-horizon roadmap development. The expected fast exponential growth (average annual growth rate 1.7-2.0) of the market of Photonic Integrated Circuits and Systems requires a solid roadmap on which the industry can rely. ■



Space-based radio astronomy

By: Mark Bentum

The human curiosity has always been challenged by questions about the Universe. Are we alone? How special is the Earth? What is dark matter? What is dark energy? And what about black holes? What is inside a black hole? And what happened before the Big Bang? These are the main research questions for astronomers at this moment in time. Monitoring the universe with different astronomical instruments will eventually enable us to answer these questions.

Radio Science

At Eindhoven University of Technology, we recently started a new chair on Radio Science. The research area of radio science is to translate our knowledge and understanding of the radio environment into science. The focus of the new chair is on radio astronomy. Radio astronomy is a subfield of astronomy that studies objects in space at radio frequencies. While astronomy, and in general the interest for celestial objects, has been studied for ages, the initial detection of radio waves from an astronomical object was made for the first time only eighty years ago. Since then, many radio observatories have been built and a number of different sources of radio emission have been discovered. These include stars and galaxies, as well as entirely new classes of objects, such as radio galaxies, quasars, pulsars, and masers. The discovery of the cosmic microwave background radiation (see Figure 1), regarded as evidence for the Big Bang theory, and the discovery of neutron stars (pulsars) were made through radio astronomy (both of the discoveries lead to multiple Nobel prizes).

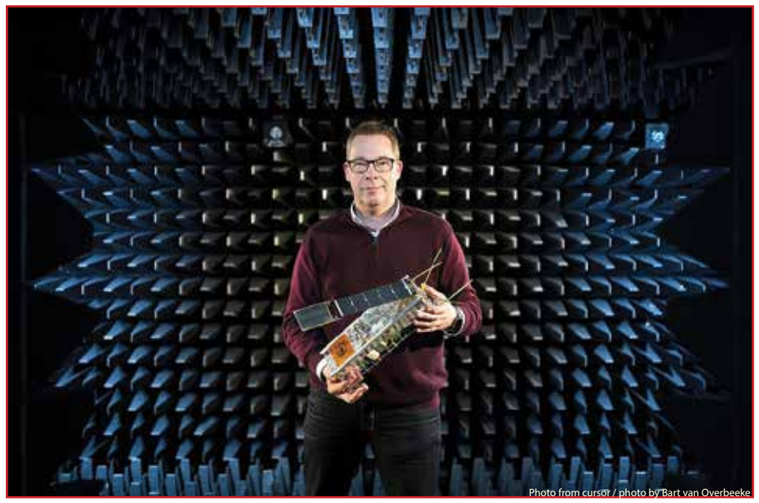


Photo from cursor / photo by Bart van Overbeeke

Radio telescopes

Radio astronomy is conducted using large radio antennas, radio telescopes. Although single telescopes are in use, most of the telescopes of today consist of many antennas utilizing the techniques of radio interferometry and aperture synthesis. The largest telescope to be developed at this moment is the Square Kilometer Array. It consists of hundred thousand antenna elements (see Figure 4). The Westerbork synthesis radio telescope and the low frequency array (LOFAR) are existing radio telescopes consisting of multiple antenna elements (WSRT – 14 dishes, LOFAR – more than 50.000 antenna elements).

Low frequency radio astronomy

One of the last unexplored frequency windows for radio astronomy is the sub-30 MHz region. There are a few reasons why this frequency band is not observed at this moment. First of all, at frequencies below 30 MHz the Earth's ionosphere severely distorts radio waves originating from celestial sources, and it completely blocks radio waves below 10 MHz. This means that radio astronomy and astrophysics below ~30 MHz is best conducted from space. Secondly, the radio spectrum below 30 MHz is filled with very strong transmitter signals, making it difficult to do Earth-based radio observations of the universe. And thirdly, the wavelengths of the signals are in the order of tens of meters, meaning that discrete antenna elements and antenna arrays are needed as dishes become very inefficient. Because large baselines are needed for spatial resolutions down to arc minutes, array antennas in phased array mode and in aperture synthesis mode are the only feasible option in space.

Location

A space mission will overcome most of these problems. Clearly, the impact of the ionosphere is eliminated and interference levels will be much lower in space. The perfect locations from an RFI-point of view will be a Moon-orbit (at the backside of the Moon), at the Earth-Moon L2 point, or at the Sun-Earth L4/5 points. A Moon orbit is a very interesting location. During the moments the Moon is shielding the possible RFI from Earth, astronomical observations can be done. At the moments the Earth is in sight, communication to and from the instrument is possible.

Science

But why is this low-frequency regime below 30 MHz interesting for solving the questions asked in the beginning? For instance, the quest to look for life in the Universe – are we alone? Answering this question, starts by finding extrasolar planets in the Universe, so called exoplanets. In the last decade, exciting discoveries of extrasolar planets have been done. The first detection of an

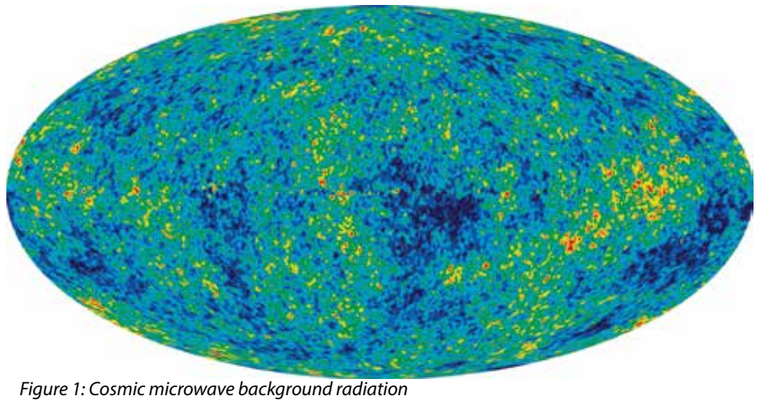


Figure 1: Cosmic microwave background radiation

exoplanets was made in 1992. While observing the timing properties of the pulsar PSR1257+12, some deviations were measured in the regularity of the received radio pulses. This resulted in a model with three nearby planets. At this moment a total of 3950 exoplanets have been discovered in 2948 planetary systems (see the website http://exoplanet.eu/catalog/ for the most actual list of exoplanets). The majority of the discoveries of exoplanets is measured by indirect means (looking at the host star and see if there are some weird effects). But, also low-frequency observations can help detect new exoplanets. The magnetized planets in our solar system (Earth, Jupiter, Saturn, Uranus and Neptune) are emitting intense radio signals resulting from particle accelerations in various places of the planetary environment. These signals have been observed. If signals from magnetized planets in our system can be detected, why not detect signals from planets outside our solar system, so-called exoplanets? This is an interesting science case, since this direct detection will prove a magnetic field on these exoplanets. And the existence of a magnetic field is one of the conditions for life.

OLFAR – the orbiting low frequency array for radio astronomy

So, we need a space- or Lunar-based radio telescope to do such observations in this low-frequency band. We propose OLFAR – the orbiting Low Frequency Array for Radio Astronomy. The OLFAR instrument uses small (nano) satellites instead of conventional micro to large satellites. A nano satellite (or cube-sat) is a small satellite with a maximum of 10 kg and is typically build by using 1 to 6 cubes of 10x10x10cm. To observe at low frequencies, a telescope with a large aperture is needed. It is impossible to launch a single massive satellite to achieve this. However, the large aperture can be achieved with multiple satellites forming an interferometer, using the same technologies as LOFAR and SKA on Earth (see Figure 2). Several small satellites can be built with off-the-shelf components, which makes them relatively faster to assemble, and inexpensive. Consequently, tens to hundreds of satellites can be deployed in a swarm. This makes the mission resistant to failure even if a few of the satellites fail, as multiple satellites provide redundancy. To achieve sufficient spatial resolution, the minimum distances between the satellites must be more than 10 km and due to interstellar scattering, this maximum baseline is limited to 100 km, giving a resolution of 1 arc minute at 10 MHz. The OLFAR's three-dimensional cluster will comprise of more than 50 satellites (preferable hundreds of satellites), each containing a dipole (or tripole) antenna, observing the sky from 0.3-30 MHz. The satellites will employ passive formation flying and yet maintain sufficient position stability for a given integration time. See Figure 3 for an artist impression of OLFAR.


figure 2: LOFAR and SKA on Earth

Breakthrough technologies

To be able to launch OLFAR, a few technology breakthroughs will be needed. Together with other partners, Eindhoven University of Technology is working on radio astronomy, telecommunications, aerospace systems, embedded systems and navigation topics. To mention a few of the fundamental science and technology challenges:

- *Array calibration and 3-D imaging.* Antenna calibration is one of the biggest challenges. The instrumental beam shape, and the frequency dependent gains of the antennas must be calibrated on the fly with minimal Earth-assistance. For low-frequency observations, the requirements on positional stability and clock accuracies are in the order of sub-meters and sub-nanoseconds respectively, which drive the navigation requirements of OLFAR. Secondly, unlike terrestrial 2-D low-frequency arrays, with the appropriately placed antennas, OLFAR will enable an instantaneous 3-D view of the sky which presents never before addressed challenges for radio astronomy imaging.

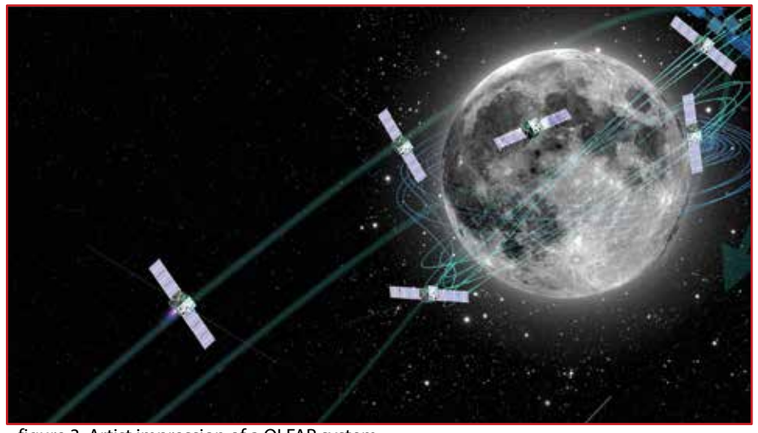


figure 3: Artist impression of a OLFAR system

-*Navigation*. The knowledge of position, time and orientation of individual satellites is vital for radio-science interferometry and for communication. However, due to the distant deployment and the number of satellites, current dependence on GPS-satellites and Earth-based ground segment are either not scalable or too expensive. In particular, when OLFAR is orbiting the far side of the Moon, the satellite swarm is completely disconnected from Earth for a few hours. This drawback calls for self-navigation or relative navigation of OLFAR, using novel techniques, for instance using pulsar-based navigation.

- *Communications and Antenna Design*. In the swarm of satellites there is a need for high data rate inter-satellite communication, both for localization and navigation purposes as well as for the exchange of data for the interferometric data processing. The total antenna system for the intended applications can be distinguished in three parts: the antenna system for the payload (the reception of astronomical signals), the antenna system for communication in the distributed space system and the antenna system for the data downlink to Earth.

- *Space systems engineering and miniaturization*. To establish a swarm of satellites of perhaps hundreds of elements, miniaturization of the elements is required.

- *Distributed processing*. The OLFAR swarm will employ distributed architectures for navigation, communication and processing science data, to avoid single point failure and to optimize efficiency.

Conclusion

At the new Radio Science chair at the department of Electrical Engineering, a novel and innovative concept for a radio astronomy at very low frequencies is being developed. As the Earth's atmosphere excludes observations at these frequencies, OLFAR, the orbiting low-frequency array, is a very attractive solution. To realize a large aperture, decentralized space architecture is developed, which consists of multiple satellites flying in formation – a so-called swarm of satellites. Each satellite receives the astronomical signals and shares these data with all the other satellites. Data processing is done in space and the processed data will be sent to Earth for further off-line processing. This concept holds a variety of opportunities and challenges which require more detailed research. The current plans for the OLFAR system to be launched is around 2030.

More information:

-Inaugural lecture Mark Bentum - https://assets.tue.nl/fileadmin/content/Research/3_Research_Groups/Electromagnetics/Boekje_Rede%20Bentum_v2.pdf

-R.T. Rajan. A.J. Boonstra, M.J. Bentum. M. Klein Wolt, F. Belien, M. Arts, N. Saks, and A.J. van der Veen, "Space-based Aperture Array For Ultra-Long Wavelength Radio Astronomy," in Experimental Astronomy, November 2015.

-M.J. Bentum, "The search for Exoplanets using Ultra-long wavelength radio astronomy," IEEE Aerospace 2017, 4-11 March 2017, Big Sky, MT, USA.

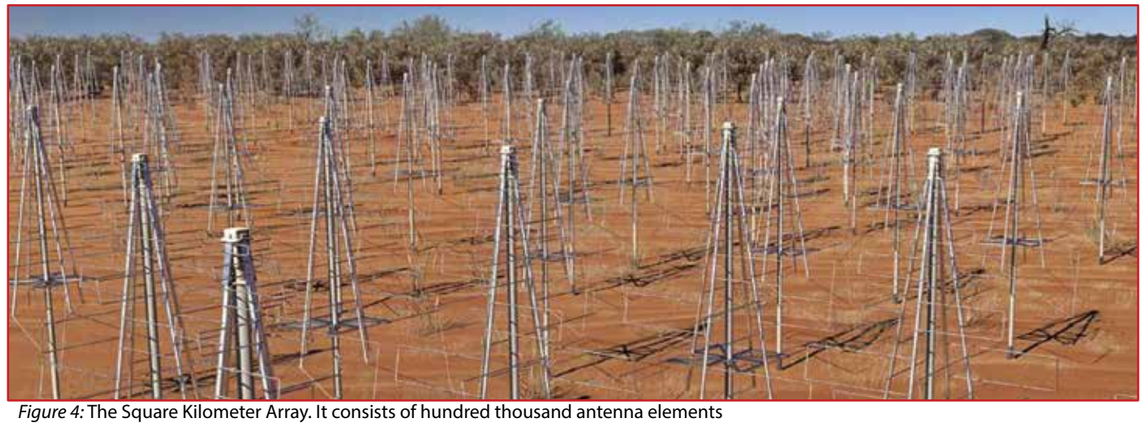


Figure 4: The Square Kilometer Array. It consists of hundred thousand antenna elements

CDC conference in Miami

By: Mannes Dreef

Finding your name on the list of speakers for an international conference for 2000 researchers in your field is truly a great honor, but also feels like something is not right. Research work done by an ordinary student in his internship can never be significant compared to the work of these established researchers, right? Even after my paper got accepted, I never got the feeling that this was happening. The fact that the conference was held in tropical Miami made it even worse. However, after extensive preparation for my presentation the plane landed and a short week of incredible experiences started.

It is not uncommon that people spend more time before or after the conference on these sunny destinations. The plane tickets are already paid anyway, and how often can you walk around the famous areas of Vice City? With a group of fellow PhD students we rented a car on Sunday and went to visit the alligator-filled Everglades National Park. Encouraged by lots of warnings to keep distance from alligators, we started our trail through some kind of marsh area hoping to see some wildlife. This turned out to be rather easy! Within the first ten meters of the trail we saw the first alligator just chilling on the side. Even the fish, turtles and birds didn't mind them and didn't care about their presence. Unfortunately, we didn't have enough time to book a boat trip and also see crocodiles and manatees, but I would say that we got a rather good value for our time in our short trip!

As we returned to the conference hotel, I should mention that it was the most luxurious hotel on Miami Beach, which is an impressive achievement in the vast amount of hotels on this island. Needless to say, this meant that everything was expensive and over the top, which was also evident in the misplaced Christmas decorations on the palm trees while it was 25 degrees. This also meant that almost nothing in terms of restaurants, bars or shops could be found in the neighborhood, because there is no reason to leave this awesome hotel, right? There was even a nightclub where Calvin Harris performed on the night of our arrival, and of course, the beach was property of the hotel as well. In short, you could easily pick the conference goers from the other guests.

Personally, being at a conference was mainly about giving a good presentation and seeing as much of the environment as possible, while still getting an idea of the work done in my area. The last part was definitely the hardest, since there were twenty parallel sessions on specific topics filled with six presentations of twenty minutes which were repeated in three blocks. In short, finding interesting topics to watch was really hard, especially since presenting skills are often not up to the standards we are used to on the TU/e.

For others, the conference is the moment to socialize and meet up, since everyone is at one place anyway. Great moments to build networks are organized in the form of the opening and closing receptions, with food and drinks of course. Next to that, there is the banquet, where fancy food is served, to the extent that this is possible for 2000 people at the same time. Besides these organized occasions you hear people having meetings all over the place, and I got invited to a lunch meeting with another American control group on topics I had barely heard about. Maybe next time I can give some more input.

Concluding, I can say that going to a conference is intense. Mainly because of the fact that you want to explore the area, while partly focusing on your research. However, all the awesome experiences that come with it, are definitely worth it.

Celebrating our 61st dies

By: Various authors

Dies dinner

This year we did not travel to a remote castle for the Dies dinner, but we went to a restaurant in the center of Eindhoven instead. It was a magical evening where a lot of beautiful stories were told, especially by those who gave a speech, and everyone drank a lot of wine and ate delicious food. I highly recommend everyone to join if you have the chance in upcoming years.

Dies excursion

This year the excursion during our Dies week went to 'Defensie'. I was very excited and directly claimed a spot when the enrollment opened. It started with an explanation about what the 'genie', the technical department of 'Defensie', is all about. This was followed by an active 'tour de genie' over the campus. In this case active meant that we were driven around in different kinds of vehicles of 'Defensie'. It was an amazing and inspiring day and I think I can speak for all participants when I say that.

Dies radio

During the week that Thor celebrated its birthday, Het Walhalla was transformed into a radio studio. Every day shows were hosted by different students and sometimes the shows started as early as 7:00h in the morning and ended just before the Flux building closed. Listeners have heard the hosts talk about many different subjects, including the news, sports, facts about goats, jokes about pancakes and much more. Make sure to listen to the radio (again) next year so you won't miss your favorite song!

Dies Beer Brewing Workshop

On Tuesday the 27th of November around 10:00h participants gathered in Het Walhalla, which was transformed into a brewery for one day. Even though the morning was quite tough for some people (which could have been caused by the cantus on the previous day), we still had a lot of fun completing all the steps of the brewing process: milling, mashing, filtering, boiling and cooling. At the end of the day, we could put our finished wort into a fermenter and let the yeast do the rest of the work. Everyone will be able to taste the result in Het Walhalla when it has had enough time to rest

Dies party

The theme of the Dies week was 'Thor versus Iron Man', so the party contained a battle element. When you entered Het Walhalla, you were divided in one of two teams. Everyone assigned to team Thor got a blue bandana and everyone assigned to team Iron Man got a golden bandana. Every time your glass was empty, you had to deliver it to the judges at the bar. This way you could score points for your team for the general rankings. Whenever there was a free keg, the delivered glasses where added to the keg round. This way, you could see which team drank the most out of the free keg. Eventually both teams won three kegs in total, but in the general rankings team Iron Man won with a difference of only seven beers! ■

Icons of EE: Steve Wozniak

By: Matthijs van Oort

Nowadays, we use laptops and desktops as if they have always been there, but about a century ago, this was definitely not the case. The use of computers has changed the way we work and eases our lives. On the road to where we stand today, a lot of iterations of computers have passed. From a big mechanical computer as big as a small house to compact devices fitting into your pocket. There are many people who were very important for this development, including Steve Wozniak, who was one of the first to develop small-sized computers.

Steve was born in 1950 in San Jose, which is part of the Silicon Valley region nowadays. Wozniak was already interested in electronics at a fairly young age, as he could be found in the garage with his father, working on all kinds of electronic projects. His father was an engineer at Lockheed and knew a lot about the physics around electronic components, which he explained in detail to his young son.

During his high school and college time, Steve had grown in his electrical engineering skills and used them for his own projects. For example, he built his own small radio, and joined the local radio broadcasting society, with the goal of contacting people from far away. A bit later in his studies, Wozniak created a blue box, which is a tone generator used to mimic the tones used by telephone operators. With this blue box, someone could freely use the telephone line to make long-distance calls. These phone calls were mainly used to perform pranks (which was one of the main activities of Wozniak). One example of these pranks is the time he and Steve Jobs tried to call the pope using this blue box. These pranks were the start of a long (and not always good) relationship with Steve Jobs, which would result in industry-changing products.

After his college life, Steve began to work for Hewlett-Packard and started designing the circuit boards for their calculators. In 1975 he joined the Homebrew Computer Club, which was a group of fanatic engineers discussing the first available computers. Because of this club, he eventually started designing computers himself with his friend Steve Jobs. The goal of their project was to show off their ideas about computers and how they could be used by the mass. Eventually, this project turned out to grow to one of the biggest technology companies in the world: Apple.

The first design he made, the Apple I, was a very basic set of circuit board designs and an operating system. At first Wozniak offered his design to HP, because he found that his employer had the right to use his design. HP refused this offer several times, and eventually Steve and Steve started selling the computers by themselves. Initially they only sold fifty system boards to a small computer shop which was interested.

After the small success of the Apple I, he started designing the Apple II. This computer would change the world because of the ease of use for the mass market. This computer was revolutionary by the fact that it could use multiple expansion slots to add extra functionality to the product. Next to this, full-color display functionality was added to the Apple II. The Apple II would be the most sold computer from Apple until the Macintosh.

Eventually, Wozniak left Apple because he did not feel it belonged to him. He did not want to manage a company, but rather do engineering with the mentality of a hacker. After he left, he started working on a universal remote controller for TVs, because he got tired of using multiple remotes for all his devices at home. Wozniak received a lot of honors for his work on computers, including the National Medal of Technology.

Steve Wozniak was an engineer by heart, and dedicated his life at improving the everyday life of others. He had more impact on the way we use computers nowadays than most people think. He helped developing a punch-card based computer system to a computer with keyboard and screen, which was available and usable for everyone. This all may seem very normal nowadays, but was revolutionary at the time it came out. ■

photo by: Justin Sullivan/Getty Images

Miller puzzle

The Miller next took the company aside and showed them nine sacks of flour that were standing as depicted in the sketch below.

"Now, hearken, all and some," said he, "while that I do set ye the riddle of the nine sacks of flour.

And mark ye, my lords and masters, that there be single sacks on the outside, pairs next unto them, and three together in the middle thereof.

By Saint Benedict, it doth so happen that if we do but multiply the pair, 28, by the single one, 7, the answer is 196, which is of a truth the number shown by the sacks in the middle.

Yet it be not true that the other pair, 34, when so multiplied by its neighbour, 5, will also make 196.

Wherefore I do beg you, gentle sirs, so to place anew the nine sacks with as little trouble as possible that each pair when thus multiplied by its single neighbour shall make the number in the middle."

As the Miller has stipulated in effect that as few bags as possible shall be moved, there is only one answer to this puzzle, which everybody should be able to solve.

Send your answer to connecthor@thor.edu before the 5th of April. ■

Previous puzzle

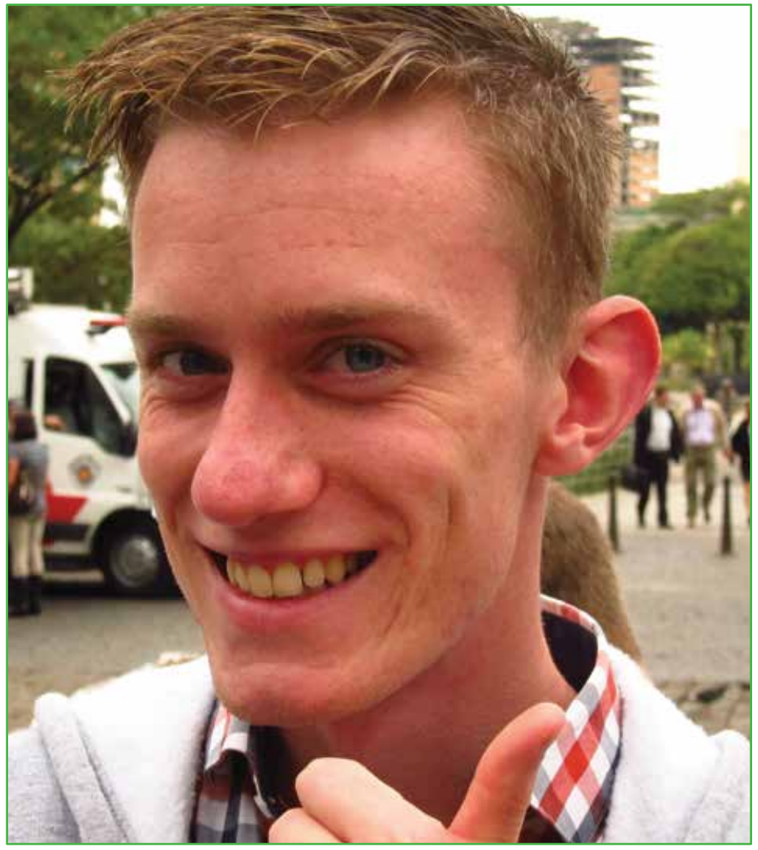
The previous puzzle in Connecthor 43 was a binary puzzle which took a lot of brain cracking before you acquired the answer. Congratulations to Jelle who found the answer in the shortest time!

Answer: 2. "As this is a very difficult puzzle, I thought it would help if I asked a simple question: What is one plus one?"

Down below you can find a QR code to all previous connecthors. If you have an interesting subject to write about send an email to connecthor@tue.nl so we can add your article. in the next edition.

Let's make it better

By: Tom van Nunen



I've been doing some calculations, and the conclusion is that I should stop paying taxes. Let me tell you why I suggest you do so too.

Everybody with a job has to pay taxes on his or her income. For a full-time job, this is usually one to several tens of thousands of euros per family. In 2017, the government received roughly 61 billion euros worth of income tax, its largest source of income, according to the CBS.

Looking at my pay slip, I see that I pay less than one millionth of this amount. One millionth! That's -60 dB, hardly, if even at all, distinguishable from the noise floor. It can't be that the government relies on something less than one millionth. I wonder whether they'll actually even notice, so I might just as well not pay it at all.

I really hope that right now you think I've become completely nuts, and that you're reading with frowned eyebrows, wondering where the heck I'm trying to go with this story. Let me explain myself.

Of course, the above story doesn't make sense. We've all agreed on the fact that everybody needs to pay taxes on his or her income. Even though each single amount is insignificant, it's the fact that everybody pays it that makes the total amount count. As soon as one person refuses to pay, and we accept it, a domino effect will occur, and eventually nobody pays any more.

The story I wrote in the beginning of this column nicely reflects the way climate science deniers, including politicians like Thierry Baudet, think about the role of the Netherlands in finding solutions to global warming. They claim that the Netherlands is so small that everything we do is insignificant on a global scale, so all money spent on it is wasted. Their solution: do nothing at all. Needless to say: they love listening to people with no serious background in climate science.

They do have a point: the direct effect of our actions will have a very small effect. Countries like the United States or China can have a much larger effect that really counts, that will make our efforts look insignificant. So, then what? Just forget about the small countries? Let them continue to pollute? Ignore the fact that the small countries can have a combined effect of equal importance?

The answer is quite similar as in the income tax story. Climate change affects all of us, so we should combat it together. Everyone should put in his or her best effort to achieve our common goals. Only when we join forces can we beat the problem.

But it doesn't stop there. The Netherlands has a rich history in innovation. For example, Dutch engineers travel all over the world to assist countries in battling the sea or creating artificial islands. What if the same happens with solutions to climate change? Wouldn't it be great if we do what we're good at: innovation?

I really foresee this happening in the near future: universities and industry join forces, combined with funding from the government or the EU, to find solutions. These become world famous, and countries line up to buy them from us.

Naïve? Maybe. Plausible? Definitely. I know for sure we have it in us to amplify the positive impact we have on global warming, by extending the reach of our solutions to far beyond our borders. I'm getting sick and tired of people claiming there's nothing we can do, because it's utter nonsense. Let's regard this an opportunity, and embrace it with both arms. It will be beneficial for our country and for the world around us. That's what I call a win-win situation.

This column was inspired by an article by Han van der Horst on joop.nl ■

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