



DELFT NO.1
OUTLOOK

YEAR
33

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2016

 **TU Delft**

PETER BOELHOUWER
**'We're always walking
on egg shells'**

SCANNING
MEDIEVAL TEXTS
**Digging for treasure
in libraries**

3D DATA
**A quick advance
of spatial models**



THEME
Robots

Cover photograph

This robot is being programmed to give lectures. He looks cute as he is, but he appears even more lifelike when he stands up from a prone position. He flexes his legs, leans on one hand and pushes himself up until he is standing.

Photo: Sam Rentmeester

EDITORIAL
Frank Nuijens

Robots

‘The notion that technology is neutral and carries no values is outdated’. TU Delft marked its 174th Dies Natalis with the theme of robotics. When they think of robots at TU Delft, most people will initially consider the technological angle. Philosopher Filippo Santoni de Sio believes that designers, policymakers, legislators, users and academics should together reflect upon the responsible use and design of robots. He makes a case for social dialogue and responsible robotics.

Self-driving cars offer us a concrete example of a field of research where automated technology and society meet. Professor of Transport Modelling Bart van Arem and his colleagues not only conduct practical tests to determine when an automated vehicle should switch to manual

control, they also examine how other road users such as cyclists and pedestrians will react to a robotic car. He expects that the technology will have further-reaching consequences, including for the spatial arrangement of the Netherlands. ‘People will be more likely to buy the house in Limburg that they had their eye on, because they can work in their car while travelling to the Randstad’. Last January, the TU Delft Robotics Institute published *Robotics for Future Presidents*, a book which sees experts introduce the role of robots in tomorrow’s world. All Delft Outlook readers receive 5 euros discount when ordering the book (see page 36).

*Frank Nuijens,
Editor-in-Chief*



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PHOTO: SAM RENTMEESTER



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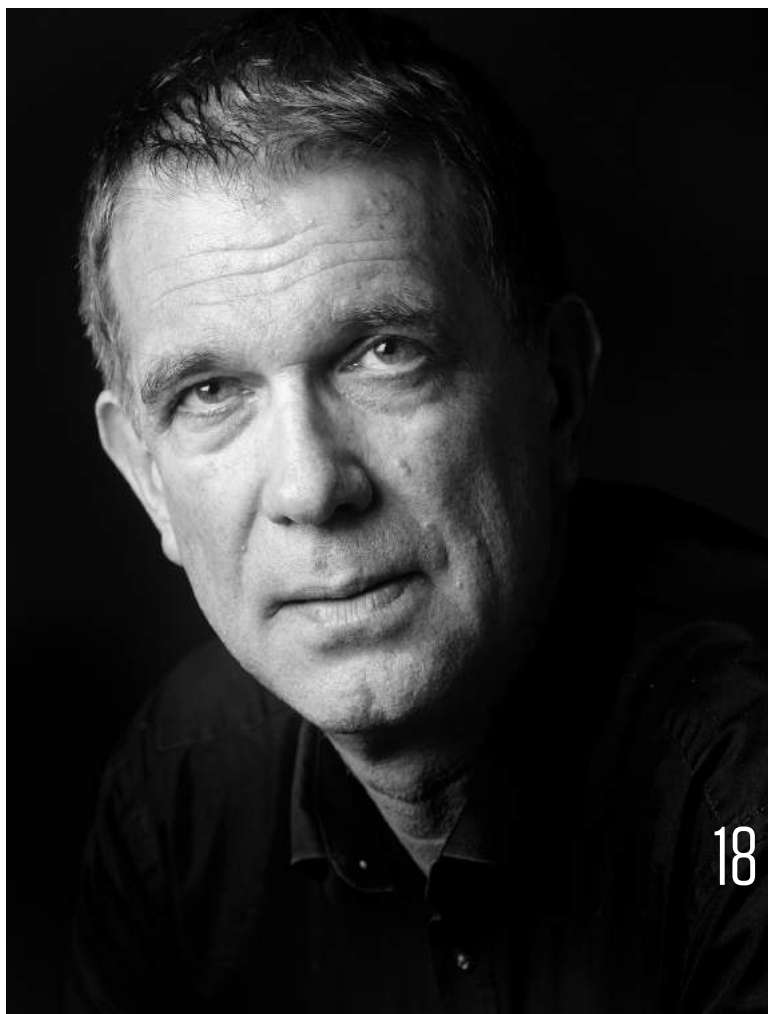
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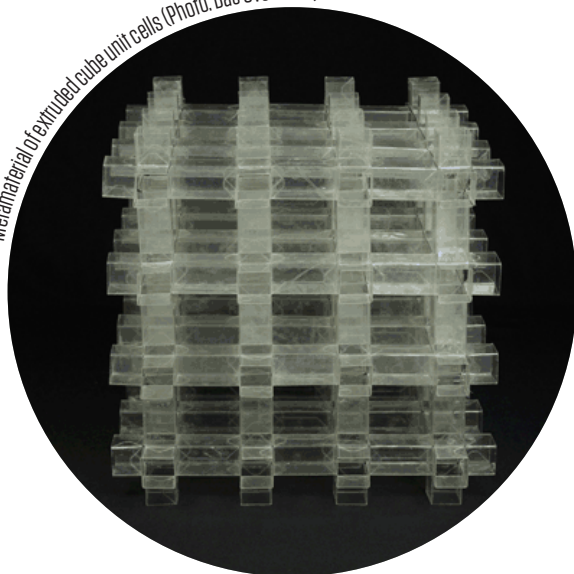
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DELFT IN BRIEF

Metamaterial of extruded cube unit cells (Photo: Bas Overvelde)



Origami

Imagine a house that you can put into a backpack. Two students from TU Delft have developed amazing foldable structures at Harvard. They made 3D material in Prof. Katia Bertoldi's lab of a controllable form and size. Their results were published in 'Nature Communications' (11 March 2016). Bas Overvelde worked there as a PhD candidate and Twan de Jong as a

graduate. They furnished the rigid surfaces with flexible folds made of air pockets and thin tubes. This enabled the entire structure (the size of a coffee table) to be controlled pneumatically. On the YouTube film, it looks more like a piece of art, and that is really what it is.
delta.tudelft.nl/31278
youtube.com/maKILHxcGAE



The new building for Applied Sciences was delivered on time and on budget on 4 February. The six hundred employees that the building will accommodate will move into their offices and laboratories in phases from 1 May. It involves the departments of Bionanoscience, Biotechnology and Chemical Engineering.

delta.tudelft.nl/31191



Learning words through play

Tactile and digital simultaneously. IDE alumna Helma van Rijn developed a teaching method for children with autism or a language development disorder that works with an app and wooden toys fitted with tags. The toy is called Linkx and consists of interactive tags and a free app for smartphones or tablets. Parents use Linkx to create a relevant learning environment for their child in advance, by speaking words into the app and linking tags to particular objects or places. The child can then go on adventure – discovering tags, listening and playing with words relating to objects or special places. Van Rijn graduated cum laude in 2007 with her initial design of Linkx.

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70 years of Studium Generale

‘Still very relevant’ is what Rector Magnificus Karel Luyben called the Studium Generale Lecture Series (SG) during the 70th anniversary of the platform, which offers students depth and breadth in addition to their degree programme. And yet it remains difficult to reach the most important target audience: students. Director of SG Coen

Vermeeren understands that younger students in particular find their degree and student life more important than ethics or world politics. ‘That said, some general issues are also relevant here. And students can choose what they find important from these.’ He looks to the future with confidence. ‘2015 was a top year with 150 activities and 20 thousand visitors.’

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Wind energy

TU Delft will convert to wind energy in January 2017. This should meet 70 per cent of the total energy needs on campus and reduce CO₂ emissions by 60 per cent. TU Delft indicated in a press release that when putting its energy supply out to tender it decided to ‘purchase 100% wind energy’. Each year TU Delft consumes around 54 million kWh, equal to some 15,000 households. In addition to wind energy, the university will continue to use its own combined heat and power plant and energy from the solar panels on its buildings.

Brain atlas for hormones

Making smart use of an existing ‘brain atlas’ provides a treasure trove of information on how hormones affect our brain. This is what researchers from the Pattern Recognition and Bioinformatics group (EEMCS) and colleagues from Leiden University Medical Centre (LUMC) published in PNAS at the end of January. The researchers applied data mining to the Allen Brain Atlas, an enormous dataset which records the activity of 20,000 genes in the brain of a mouse.

Stress and sex hormones have a great impact on the brain, for example on memory and emotions. But it is still unclear which areas of the brain are affected by which hormones and exactly how this works. By looking at which genes in the same area in the brain are active as the genes that are responsible for making the hormone receptors, the researchers were able to discover all kinds of relationships. For example, the researchers saw that oestrogen and cortisol are both able to control several areas in the brain at the same time.

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Smart Neanderthals

Neanderthals were anything but stupid. Researchers from TU Delft and Leiden have discovered that these primeval people used manganese dioxide to make fires in caves in France some 50,000 years ago. Manganese dioxide is a dark-coloured mineral which we knew Neanderthals used to decorate themselves with. However, the use of manganese dioxide to make fire is not known among modern-day hunters and gatherers. It is therefore a unique discovery that provides insight into the cognitive capabilities of Neanderthals, wrote the researchers in Scientific Reports at the end of February.

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Making drinking water

Try making drinking water with nothing more than plastic, sea water and lots of sun. It sounds like an assignment from a survival programme, but access to safe drinking water is a daily concern for 750 million people. Dr Rajat Bhardwaj saw the need at first hand when he taught in a slum area in Mumbai. He was determined to develop technology that would enable people to make their own safe drinking water. The chemical engineer developed a water filter at the company Dr. Ten and obtained his doctorate under the supervision of Prof. Rob Mudde (Faculty of Applied Sciences) on the subject of an inflatable water dome in which salt water evaporates before condensing into drinking water.

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PHOTO: RAJAT BHARDWAJ

An inflatable water purifier.

DNA bands

It was a world first. Insiders knew that the condensin protein plays a role in the folding and fixing of DNA strands, but no one had ever seen how this occurred. Since Jorine Eeftens and Allard Katan from the Cees Dekker Lab (Bionanoscience) published on the subject, that has all changed. In their film and in the cover article in 'Cell Reports' (1 March 2016), they demonstrate that condensin is a much more active and more flexible molecule than first thought. 'Until recently, people saw it as a kind of hairpin with two positions: open and closed,' explains Eeftens. 'But a better comparison would be an elastic band.' It was the first time that the protein was filmed in action with an atomic force microscope (AFM).

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PHOTO: ROY BOURGHOUTS

Jorine Eeftens and Cees Dekker with the AFM microscope.

Delft on the map

In the lavishly illustrated historical atlas of Delft ('Historische atlas van Delft'), TU alumnus and urban planner Stef van der Gaag has divided the history of Delft into five blocks: peat excavation, trade and manufacturing, industry, engineering education and city among cities. He also describes extensively how TU Delft developed out of the Polytechnic School (1864), the urban development of the university district, the Technical College during the post-war reconstruction years and the development of the TU Delft campus in the 21st century. Published in 2015 by Vantilt, price: 29.50 euros.

delta.tudelft.nl/30995 en [30735](http://delta.tudelft.nl/30735)



THEME

Robots

Robots that can keep watch, shake hands, furnish rooms, design bridges or even join you in bed. Nothing is out of the question when it comes to making our everyday lives easier. A range of research conducted at TU Delft shows that this is all technically viable. But ethical considerations are not being overlooked. An overview of robotics at TU Delft.





Robots about the house

The robots are coming, as we've been hearing for quite a while. Nearby, in The Hague, scientists, engineers and TU Delft students are working on robots we might encounter in the coming years, for instance in an abandoned factory.

Racks, stacked sky-high. Dozens of them, row after row. He entered unseen, but without proper directions he would never have found the compartment where the latest iPhones are stored. Just try to make sense of the jungle of barcodes hanging here. Easy navigation for a picking robot of course, but totally useless for a human being. Then again, this hall isn't meant for humans. He only has to climb up a metre. That's not too bad. As he holds on to a post with one arm and fumbles around inside the compartment with the other, he glimpses a device approaching around the corner. It resembles a moving trash can, apart from the haze of purplish light beneath its bulk. Rolling at considerable speed, the robot navigates between the racks. Just keep hanging quietly and nothing will happen. Suddenly, the robot stops. Its purple light turns red. A camera under its plastic dome turns his way. It makes a sound: "Shunplees". The robot approaches, the camera swivels up, and a light turns on around the lens. "Identification, please." Now he understands. Silly thing. He jumps off the racking, kicks the robot and runs away.

"If you kick it over, the robot has already done its job," says Edwin Lustig (46), executive director at Robot Security Systems. "It has seen you and reported you. It can't do anything more, but it doesn't have to. Surveillance officers are already on their way and will go looking for you. That remains a job for humans." Robot Security Systems supplies a robot called SAM for surveillance work. There are now a few of them rolling around in the Netherlands and in Belgium. Lustig expects that there will be twenty in a year and hundreds within five years. Robot Security Systems, together with Robot Care Systems and Robot Engineered Systems, are subsidiaries of the Robot Robots Company holding in The Hague. In early February, the company was in the news because it had collected five million euros in investment funding from Rabobank, the investment company Innovation Quarter and health insurer CZ, among others. Delft-based Professor Pieter Jonker (3mE) is co-director of the holding company, while – for example – his former PhD student Dr Maja

Rudinac is in charge of the Robot Care Systems subsidiary. Robot Care Systems works on a robotic walker called LEA for geriatric care; Robot Security Systems develops and provides SAM the surveillance robot, and Robot Engineered Systems designs tailor-made robots, including the autonomous vehicle WEpod. This showpiece will drive between Ede-Wageningen station and the Wageningen University campus in June.

Sensors

"We do not make robot bodies", Lustig clarifies. He estimates that robot SAM is a procured platform for 60% and 40% self-built. What RSS adds to the mix are primarily sensors and sensor data fusion and intelligence. The actual production of robots also happens outside the company. Here, on a floor and in the basement of the Lobeco Fire + Security company near Benoordenhout in The Hague, forty men and women employed by Robot Robots Company and its subsidiaries, most of them originating from Delft University of Technology, work on



PHOTO: SAM REINTMEESTER

Edwin Lustig supplies a robot called SAM for surveillance work. There are now a few of them rolling around in the Netherlands and in Belgium.

robots that can collaborate with people in clever ways to the benefit of security, geriatric care and passenger transport.

Cognitive robotics

“We procure a blind system, and teach it how to see”, explains Jonker, the man who introduced robot soccer in the Netherlands. This professor of Intelligent Vehicles & Cognitive Robotics envisions ‘seeing’ – i.e. perception – as the beginning. After that, the questions start: Where am I? What is coming at me? And what should I do about it? That brings us into the field of cognitive robotics.

“A security company does not provide a guy with a moustache; it supplies security through cameras, surveillance cars, security guards, an emergency centre and possibly a robot. The robot can take on a number of jobs, including surveillance. A


robot will probably do that job better than a security guard who is making the same round for the umpteenth time and is mostly focused on getting back to his post as soon as possible. If a security company can deploy 1.5 to 2 fewer people,

We procure a blind system, and teach it how to see

they will be able to lower their price bids considerably”, says Lustig, who has worked in the security industry for fifteen years. “In those days, I apprehended three intruders, but I fired twenty employees for sleeping on the job.” Robots do not have those problems.

Jonker (aged 64) launched a business alongside his professorship to

safeguard his research legacy after he retired, since it was unclear if he would have a successor. The whole adventure has taught him a great deal about putting his knowledge into practice. “We have had a time when the emphasis was on publications. That is all nice for the rankings, but it does not put the technology on the market in the Netherlands. That only really happens when you bring a bunch of your graduates together in a company. Pieter Kruit (AS) did that with Mapper. He was my role model. I do that with my companies too now. And I’ll have more time for it as from next year.”

The irony is that Jonker will in fact have a successor as of 1 April 2016, namely Dr Darius Gavrilla, originally from Daimler Chrysler, who will focus mainly on data fusion, pattern recognition and deep learning in intelligent vehicles. 



Do a search for ‘robot hand’ online and you’ll soon come across mechanical metal constructions with humming actuators. “It gives you a queasy feeling. They look like claws”, says Professor Jo Geraedts. His engineering graduate, Rob Scharff, made a friendlier version in the first ‘soft robotics’ project at Delft University of Technology.

From steel claws to soft hands

Robot hands often resemble cold claws, and that’s not so strange at all. Robot development started in electromechanical engineering, where researchers tried to copy movements by means of actuators and springs, ratchets and screws. That led to complicated constructions. “The literature mentions hands with twenty actuators”, says Geraedts.

About ten years ago, researchers started wondering if that couldn’t be done differently, says the mechatronic design professor. 3D printing emerged, with which it became possible to print complex structures in layers just 10 micrometres high, layer after layer, using materials with various properties, such as rigidity. Another development concerned the use of techniques drawn from nature. An elephant, for instance, has muscles in its trunk that are coiled like a helix. By contracting those muscles, it can twist its trunk in various ways.

Scharff combined those two things, emulating that effect through 3D printing.


“By rotating a bellows over a helix, you can create a wrist-like rotation using air pressure”, Scharff says. In soft robotics, control is based on force, not position. “When you grab something, you stop at a certain exerted force instead of at a certain location”, Scharff explains.

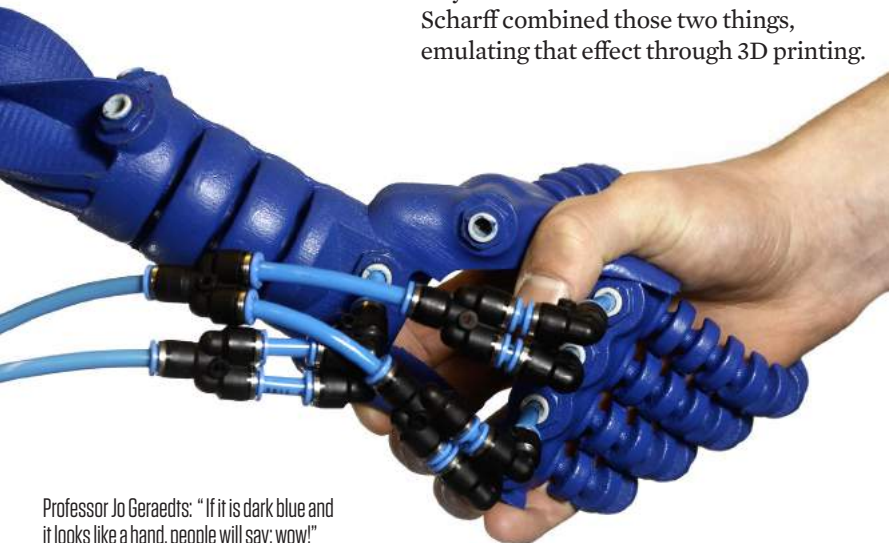
The thing is to emulate the human sense of touch. That has big advantages compared to mechanical control when grasping objects. “Especially if an object is slightly bigger or is situated a bit more to the left or right”, Scharff says. It is also safer. “Using soft materials and force-controlled movements

Soft robotics emulates the human sense of touch

facilitates human-robot collaboration.


You can even touch the robot. And – as in the case of my graduation – shake its hand.” The dark blue, flexible hand that Scharff developed in collaboration with the Belgian company Materialise contains air chambers. If you squeeze those, the pressure increases. The robot ‘feels’ that you are shaking his hand. The firmer your grip, the higher the pressure in its air chambers, and the firmer it ‘squeezes’ back.

All movement happens by means of air, using a compressor. “So, you don’t need any electronics in that hand, which also makes it possible to work with fluids and sand”, Geraedts says. Possible applications include active orthotic devices, a glove for example. “If it’s a thing with five shiny metal claws that makes noises, it just doesn’t feel right. If it’s dark blue and looks like an actual hand, people will say: ‘wow!’” 



Professor Jo Geraedts: “If it is dark blue and it looks like a hand, people will say: wow!”

Taking a robot to bed

Giving Somnox a firm hug makes it mimic your breathing and slow it down. Research has shown that you unconsciously adopt its calm breathing pattern, making it easier to fall asleep. Third-year Computer Science student Job Engel demonstrated the huggable sleep robot for people with insomnia at the Exhibition of Minors. Industrial Design Engineering students displayed their prototypes from various minors, including robotics. 





Mini-drone flies like a bee

Gauging distance with one eye is tricky. That also applies to robots with one camera and to bees with eyes set right next to each other. By understanding more precisely how drones land, researchers have now also gained more insights into bee behaviour. Guido de Croon of the Micro Air Vehicle lab at the faculty of Aerospace Engineering published on this topic last January.



PHOTO: SAM RENTMEESTER

Guido de Croon: "This study originated from frustration, because it turned out to be impossible to execute a fast, smooth landing using optical flow."

If you approach an object with only one eye open, you can see it grow bigger, but you don't know exactly how close you are to that object. As you approach, the object's apparent size grows more quickly; this is also known as optical flow. By keeping this optical flow constant, a drone automatically slows down as it gets closer to its objective. Researcher Dr Guido de Croon wanted to use a constant optical flow to make drones land automatically, but that turned out to be trickier than expected. "This study originated from frustration, because it turned out to be impossible to execute a fast, smooth landing using optical flow. By the end of the approach, the drones kept on oscillating up and down", De Croon explains. "At first I thought that the imaging software did not perform well enough close to the

ground, but later on I discovered that the effect was also present when using perfect imaging." Theoretical analyses showed that the oscillations were caused by the much

'I cheered in the lab because a flying robot was on the verge of losing control'

greater effect on the optical flow from movements close to the ground than from a greater distance. This led to a new angle for De Croon: he decided to make use of the apparently inevitable oscillations as an indicator to initiate the final landing. De Croon: "What I like so much about it is that the robot actually uses the instability of its own control system as a way to gauge

distances, so that it can determine when to shut down the propellers, for instance. Over the past months, people have been giving me odd looks whenever I cheered in the lab because a flying robot was on the verge of losing control", De Croon says. By changing the amplification during the descent, the drone will approach the ground automatically while oscillating until it shuts down its engines at a height of a few decimetres and then plops onto the mat. And that looks suspiciously similar to what bees do: they also hover briefly at a certain distance from their landing spot. The new theory that De Croon and his co-workers at the MAV lab have published in the journal *Bioinspiration & Biomimetics* (7 January 2016) offers a hypothesis on how and why a bee behaves like that. **WV**

Patient or pilot

If your legs are paralysed, everyday activities like getting up off a deep sofa, walking over rough terrain or going upstairs are impossible. Or are they?

TU Delft students are working on a robot suit for paraplegics. The group of students in the March team are the latest addition to the Dreamhall, the workplace in the faculty of Civil Engineering and Geosciences where student teams work on a range of projects, including the Nuna solar car and the human-powered Wasub submarine. In October, they intend to compete using their exoskeleton at the Cybathlon in Zürich, the world's first bionic Paralympics.

They still have a prototype that was the result of a previous collaborative project between TU Delft and the University of Twente – the Mindwalker. It is a bulky suit with large buttons. “It was originally hoped that patients would be able to control the suit with their brain, using EEG signals”, explains March’s PR man, Sjoerd Butter. “But that was asking too much of the technology.”

Instead, the students came up with an alternative approach. They have equipped the robot suit with numerous sensors, so that it feels natural to control. As a result, the exoskeleton senses what the patient wants based on only minimal movement. They themselves prefer the term ‘pilot’ to that of ‘patient’. At the base and back of the suit are sensors that register when the wearer bends slightly. The robot will then realise that the pilot wishes to stand up and provide assistance. The patient – or pilot – will also have to use a remote control.

The suit itself needs to fit much more

closely to the body. The students aim to achieve this by means of 3D scanning and printing technology. “Another new aspect of the design is that the robot will have five degrees of freedom in each leg, two of which will be in the hip, in order to enable natural walking movements”, chief engineer Nick Tsutsunava explains. “The question is: will the exoskeleton walk with you, as is currently the case since they make pre-programmed movements, or will you walk with the exoskeleton? Of course, we are making the latter happen.” **TVD**



Robotic arms building bridge

It will be a first for Amsterdam. Next year, drunk hooligans and other visitors to the Red Light District can find their way from one side of Oudezijds Voorburgwal to the other via a steel pedestrian bridge put together by robots using a 3D-printing technique.

It is the brainchild of designer Joris Laarman. He is working on the bridge with TU Delft researchers, including IDE’s Dr Jouke Verlinden. “The great thing about steel is that you can use it to make slender lightweight truss structures that are extremely strong because they bear the weight optimally”, Verlinden says. “We are using a welding technique in which two robot arms build the bridge drop by drop”, Verlinden continues. “This principle has had very little research conducted into it. It is a repetitive and very precise process, releasing a lot of gas and radiation, so really needs to be done by robots.”

The original idea was to have the robots put it together in situ, at Amsterdam’s Oudezijds Voorburgwal, but that was too dangerous. “The Council refused to allow it.” The bridge will have a span of eight metres and will be built in Amsterdam at the start-up MX3D, co-founded by Laarman. Earlier this year, their workshop produced a complete 3D-printed steel bicycle, also made in alliance with people from IDE. **TVD**



‘Teamplayers come to your assistance’

How does collaboration with robots work? Professor Catholijn Jonker, Interactive Intelligence research group leader in the faculty of Electrical Engineering, Mathematics & Computer Science, explains the TU Delft vision.

On Foundation Day, you gave a lecture on interactive intelligence. What is that?

“We see it as research in which we focus on robots as team players rather than as a tool. You can use a tool when you need it, but a team player can see that you need support if, for example, you cannot open the door with a box under your arm, so comes to your assistance.”

Are team players robots that understand what people want and respond to it?

“Not only do they understand what people want, they also know that they may be perceived as a threat. For example, drones are expected to keep their distance and not graze past your head, even though that would be safe. Human experience needs to be taken into account in the design. This means not only looking at what is technically possible, but also taking account of standards and values in the way people behave.”

Are you aiming for friendly and helpful robots?

“If you want to take a robot out of the secured cage in the factory, this will involve considerable interaction. This means that robots need much more awareness of their environment and of people than they have so far, which calls for significantly more intelligence.”

So far, human-robot interaction has mainly been via a keyboard or touchscreen. Is that set to change?

“Haptic technology has now emerged and can be used to bring the robot arm to where you need it. It’s physical manipulation instead of entering



Prof. Catholijn Jonker; “The aim is to make robots smart enough to collaborate with people.”

coordinates. If you simply have to demonstrate the required action to the robot, it can be operated by someone with a relatively basic education. However, the programming required to achieve that is quite complex. The aim is to make robots smart enough to collaborate with factory workers.”

What is the advantage of using a robot in a factory?

“We can delegate all kinds of activities that we do not wish to do or are not very good at. This will have an impact on the world of work, but these changes have been underway for the last two centuries.”

What are the main dangers to society from robots?

“The fact that things need to be done in the way that robots are capable of doing them and not in the way that we feel they should be done. With today’s ICT, you can accidentally end up hiring a car for a whole week, even though you only wanted it for the weekend, and there’s nothing you can do about it. The helpdesk may understand the error made, but can’t actually help because ‘the system’ doesn’t allow them to refund the excess amount paid. Exactly the same can happen with robots. I regard this as a dangerous side-effect that we must do our best to minimise. But given the developments in ICT, I am not too optimistic, since it is nice and cheap to create an inflexible system.”

Shouldn’t people be more assertive when it comes to impractical ICT applications?

“I think so. But they will also need to be prepared to pay. That’s the disadvantage. Creating intelligence does not come cheap.” **JW**

‘We need to think about responsible design and use’

We must not fill the world with robots without first seeing how they influence humans. Instead, society needs to focus first on their responsible design and use. This is the view of philosopher Filippo Santoni de Sio.

The idea of robots taking over the world is a fascinating future scenario. But Assistant Professor of Ethics and Philosophy Filippo Santoni de Sio (TPM faculty) would rather start thinking about the issue now, while robots are not quite so smart yet. In order to protect society from the undesirable consequences of robotisation, he calls for a debate in society and responsible robotics. It is up to people to take responsibility, he argues. Designers, policy-makers, legislators, end users and scientists will all need to put their minds to the

issue of the responsible design and use of robots. This is because the idea that technology is neutral and value-free has become outdated, according to Santoni de Sio. “There is no point in saying about a rifle that it’s only a tool, and that tools do not kill, people kill. The fact is: more people die in places where there are weapons.”

He also feels that society should not regard new technologies like robots

‘The idea that technology is neutral and value-free has become outdated’

as a *fait accompli*. “We must avoid filling the world with robots that are then impossible to avoid. First we need to think about their design, about legislation and about the social consequences.”

In Santoni de Sio’s view, there are

currently four controversial questions relating to robots. One of them is the extent to which we should use robots in healthcare. “They can be extremely useful for surgery, but the same probably cannot be said about providing company to lonely old people.” Another issue, which is attracting attention as high up as the United Nations, is whether autonomous weapon systems should be permitted in the military. “That is an area that requires precaution, especially since the military world lacks transparency.”

The third issue involves robots and employment. “How far should we go in allowing robots to take over people’s work? What if that results in large-scale unemployment, with the robots in the hands of a small group of powerful companies?”

The final example that Santoni de Sio cites is the self-driving car. He is involved in research into this within the Delft Robotics Institute. He has doubts as to whether they will ever drive independently on the open road, however hard a developer like Google may lobby for it. “But the technology is unstoppable, so we should approach it responsibly. Developers need to be aware of the options available. Various levels of autonomy are possible. You can also devise a completely new transport system with its own infrastructure for self-driving vehicles, regulated by a public authority.” He also feels that society is failing to address questions along the lines of “Who is responsible in the event of an accident?” Ultimately, he believes, we will find a solution to all this. “Prohibition is definitely not a good idea. That would be an overly conservative approach.” **SB**



Philosopher Filippo Santoni de Sio would like us to think about issues as: who is responsible in the event of an accident?



Self-driving car needs driving lessons

Making self-driving cars is one thing, but allowing them on the roads in large numbers is something else.

TU Delft has two automatic vehicles. One is in the 3mE faculty and the other in Civil Engineering and Geosciences (CEG). It is the latter faculty is where Professor Bart van Arem works. In addition to being Director of the TU Delft Transport Institute, he is co-founder of the Dutch Automated Vehicle Initiative (DAVI). DAVI aims to promote automatic driving on the road, in order to learn from it. TU Delft is currently in the process of developing the sensors for its two automatic vehicles, two Toyota Priuses, Van Arem explains. They will take to the road later this year. "Initially, they will have drivers, in order to test whether the vehicles can effectively

recognise the world around them. We can then go on to test automatic acceleration, braking and steering." The problem is not the automatic driving itself, since the software for that is built in. The problem is that robot vehicles need to anticipate the unexpected. That requires very accurate positioning. The car also has to know what traffic regulations apply and which users and conditions there are on the road. "We will be driving through a digital cloud", Van Arem predicts.

In order to gain insight into other road users, he and his colleagues are conducting a range of practical tests: When is it necessary to switch to manual steering? How do drivers behave when following other vehicles or changing lanes? How do pedestrians and cyclists respond to a robot vehicle? "I expect that cyclists and pedestrians will get used to them and anticipate accordingly."

Van Arem is in charge of a major

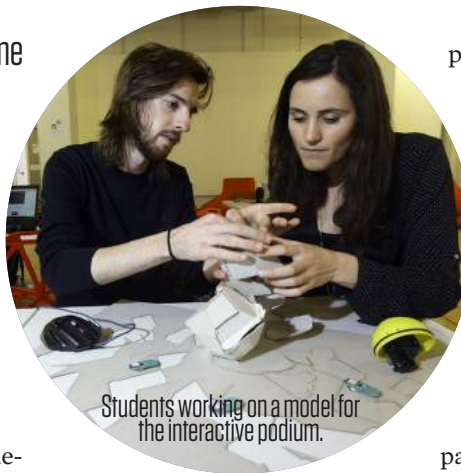


research project on the spatial and mobility impact of self-driving cars. They will bring about a complete change to how the Netherlands is organised spatially, the professor argues. "People will be more likely to buy a house in Limburg, because they can work in their car while on their way to the Randstad." Van Arem expects this to be possible in ten to fifteen years, on specially protected roads." **SB**

Spatial robotics

The Robotic Building research programme aims to develop techniques by which robots can lay out spaces for a variety of uses.

Protospace is a workspace in the faculty of Architecture and the Built Environment where students design interactive spaces. The research is being conducted within the Hyperbody group led by Prof. Kas Oosterhuis and aims to develop techniques and methods to make architecture interactive. As an example, Dr Henriette Bier cites spaces that can adapt to different types of use. "Many buildings are empty for two-thirds of the time. Densely-



Students working on a model for the interactive podium.

populated cities, such as those emerging in Asia, can no longer afford such inefficient use of space."

Twenty students are currently working on an interactive podium for Oosterhuis's valedictory symposium. This will be the third session of the Game, Set and Match series exploring the boundary between real and virtual reality. The aim is for the robot-controlled stage to provide everyone with a chair, virtual participants with a screen and dancers with all the space they need by moving things or folding them away. **JW**

View

What future awaits us? In twenty years' time, will smart robots be assisting us with all kinds of household chores? Will they be driving us around and taking work off our hands?

If anyone is qualified to speak on the subject, it is Prof. Robert Babuska, founder and Director of Research at the TU Delft Robotics Institute. "I predict that robots will increasingly start doing the heavy and repetitive work in industry and agriculture", says Babuska. "The kind of work that people shouldn't do and makes them ill. We need to bring an end to that kind of work.

Robots will also increasingly take on dangerous jobs. Inspecting fuel tanks, for example, or investigating the scene after a disaster. And they will also play a major role in healthcare. Good healthcare enables people to live longer, including those suffering from disabilities. Self-driving robots and exoskeletons can make it easier for people with mobility problems to get around."


So, robots will take people's jobs? "No, I don't think that will happen", Babuska replies. "All of these robots will complement people. And these developments will not happen overnight, so society will have time to adapt. In the short term, I expect to see increasing numbers of so-called collaborative robots. Robots

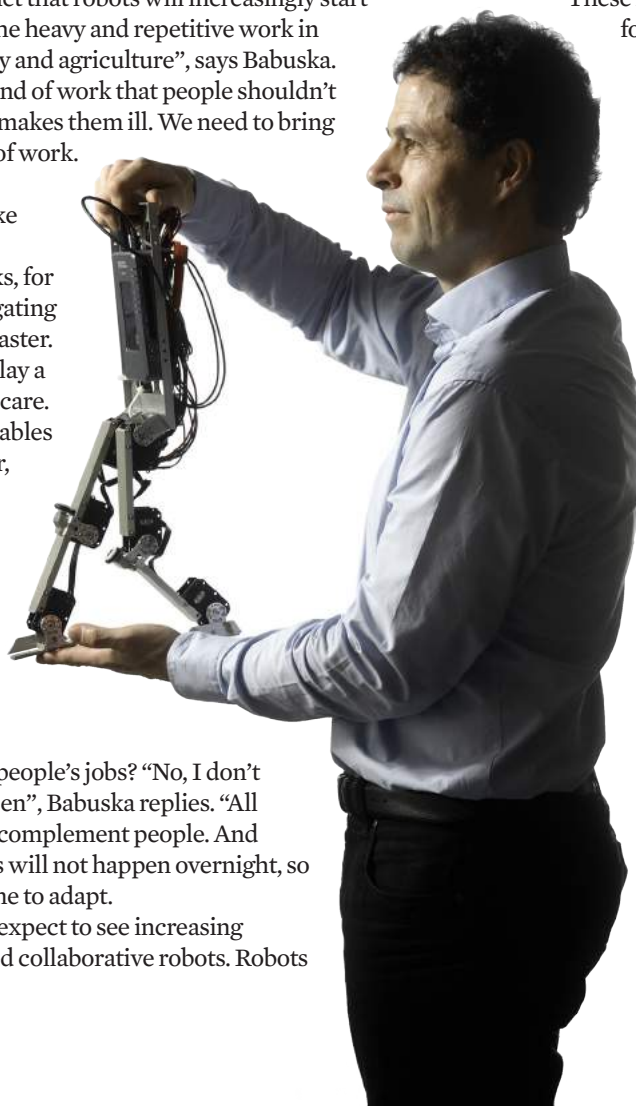
like Baxter, which we use at TU Delft for certain research projects. Baxter is a robot whose arm you can grab and move. By doing this, you program it for that specific movement.

These robots are inexpensive and can be used for a wide range of simple activities, such as screwing bolts or wrapping parcels.

In the medical world, developments are moving very slowly. Currently, therapeutic robots and exoskeletons often still contain motors in the hinges. These are large and heavy. I think we will need to develop artificial muscles.

At the moment, robots are mainly used in the automotive industry. The robots used are large, powerful machines that do repetitive actions with great precision. They have very little integrated dexterity, but are programmed for set movements.

As soon as you allow robots to operate in a world that changes, you bump into a variety of different problems. Take, for example, a robot that has to pick tomatoes. Every bunch has a slightly different shape. What is the best way to pick them? That will vary from case to case. And when is a tomato ripe? The robot will need to recognise that. There are all kinds of different things that cannot be pre-programmed completely. The robot needs to respond on the fly to its environment, which is not known in advance and may be dynamic. It is an enormous challenge to equip a robot brain for achieving that." 





‘I don’t want to stand on the sidelines’

His report was not called into question. “But the pressure was extreme.” Professor of Housing Systems Peter Boelhouwer studied the housing market and liveability in Groningen’s earthquake zone.

TEXT: TOMAS VAN DIJK PHOTOS: SAM RENTMEESTER



CV

Peter Boelhouwer is Professor of Housing Systems and Head of OTB – Research for the Built Environment in the Faculty of Architecture and the Built Environment. He is a member of the supervisory board of a housing corporation. He is also editor-in-chief of the Journal of Housing and the Built Environment and belongs to the editorial board of various scientific journals. In addition, he is the chairman of the European Network for Housing Research, the Netherlands Graduate School of Urban and Regional Research (NETHUR) and the Knowledge Foundation Problems (KCAF).

Residents with psychological problems, fear of buildings collapsing and thousands of damaged homes: Professor Peter Boelhouwer's research on the housing market and liveability in Groningen's earthquake zone did not leave him unaffected. He presented his findings along with those of seven OTB – Research for the Built Environment colleagues to Hans Alders, the National Coordinator for Groningen, in a packed room in the village of Bedum at the start of this year.

For a period of nine months, the Delft contingency polled residents in nine high-risk municipalities and analysed statistical models in order to calculate the drop in housing prices. Their work was commissioned by 'Dialoogtafel Groningen', a consultative group of involved and affected parties. The group was appointed in March 2015 to help restore trust in Northeast Groningen.

The important conclusions of the report include: 29 percent of the households in the risk areas feel unsafe and people in 4,000 households are suffering from psychological problems. Generous compensation from the Netherlands Petroleum Company (Nederlands Aardolie Maatschappij – NAM) was out of the question.

Reading between the lines, it is clear that you feel NAM is too passive.

"Much more generous compensation is important. Many people are afraid that they will not be able to sell their house. The sense of not being able to escape is horrible. A buying up scheme would give people renewed perspective. Money should not be an issue. Some 211 billion euros worth of gas has been extracted from this region over the past decades.

The renovation of houses needs to be tackled more effectively, too. Three thousand homes should have been renovated in 2015. NAM have only fixed up 23 of these."

Was it difficult to preserve your independence in this politically sensitive issue?

"I dove in headfirst with this study. 'What am I getting into?' I wondered. Never before have I encountered such an extreme divergence of interests. It was a hornet's nest. Everyone tried to put pressure on me. Right to the very end. Members of the supervisory committee wanted the press release to say that the method of depreciation used by NAM was no good. And that the study would provide proof. That was incorrect. I had to remove it from the press release. We were not the

supervisory committee's pawns. But we had to really stand our ground.

"I strove for the appropriate tone in the report. The urgency and desperation of the people were effectively incorporated. As well as the perspective that can be offered to them. If a fair compensation scheme materialises and the houses can be properly reinforced, most people have no interest whatsoever in moving out of the area."

Were you shocked by the findings?

"I had done my homework on the area, of course. But the study and the findings really affected me. What the residents are going through is very intense. People talked about their grandparents not being able to have their grandchildren stay overnight anymore for fear of their houses falling down. And parents described the sense of relief every time their children returned from school safely.

'You don't show any emotion' I was told during the first meeting during which I presented interim findings to a room of several hundred residents. I was trying to be professional. Now the first thing I do at these meetings is to share how it also affects me, and that it is a serious issue. Sometimes I would be talking with people and they would suddenly lose their temper. Of course, NAM lied to the residents for years. 'No, there is no connection between gas extraction and earthquakes.' Then the major tremor hit near Huiszinge in 2012. From that moment onward it was impossible to deny. Groningen has thousands of quakes each year. Personally I have never experienced an earthquake. I try to imagine what it's like. You're sound asleep and suddenly your entire house is shaking."

As Professor of Housing Systems you frequently work on politically and socially sensitive subjects. Had you ever experienced anything like the pressure accompanying the study in Groningen?

"I was on the Housing, Spatial Planning and Environment Council for years. Together with other experts I advised the ministry on housing market reforms. A very sensitive topic. Maintaining your independence is key. Our recommendations were often taken out of context. That was the case involving my recommendations regarding special loans for first-time buyers, for example. I am positive about loans for first-time buyers, just not when the market is overheated. You shouldn't offer



them under those circumstances. People tried to put all sorts of words in our mouth. We are constantly walking on eggshells.”

What trends do you see in the housing market?

“Scarcity is growing. There is not enough new construction. Especially considering the ongoing increase in immigration. This, too, is a sensitive issue. The Government Architect says: ‘No, you shouldn’t build new homes; you should convert unoccupied office buildings into homes. Vacant buildings look bad. And allowing office buildings to remain wempy is destruction of capital.’”

You disagree?

“Doing something about lack of occupation is fundamentally a good thing. But we’re not going to solve the problem just by tackling vacant office buildings. Besides, you’re not even allowed to live in many offices because they are too close to a motorway. We spent years building Vinex districts. That project is now finished. Now we are building fewer than 50,000 homes a year. That’s far too few. By 2020 the housing shortage will have increased from today’s percentage between 2.5 and 3 to 3.7 percent. Prices are going to soar as a result. You will see people living at home with their parents longer, or taking up residence in caravans. In London it’s not uncommon for many families to share a house. London is our future. Things will go that way here, too, if the Chief Government Architect has his way. Cities will be

the exclusive domain of the super-rich. Is that good or bad? To me it doesn’t sound very appealing. But really it depends on your political perspective.”

You have been accused of being a straw man for the building sector.

“I have been accused of that, yes. Especially in connection with the Owner-Occupied Properties Monitor that we conduct four times a year and in which we write up the trends in the owner-occupied housing market. I feel that I should express my opinion. What I do is socially relevant. I don’t want to stand on the sidelines. When I was a student I decided to focus on housing because I thought it was socially relevant. Those were the 1980s; the era of the squatters’ movement. That movement had a point. There were not enough houses. Especially for young people. They were

‘People try to put all sorts of words in our mouths. We are constantly walking on eggshells’

exploited. I was never a squatter. I got involved with the politics through the city council. Once again we’re heading towards massive housing shortages. Believe me, it’s going completely pear-shaped.”

Do you see any positive sides to the housing market crisis?

“The good thing about the crisis is that it forces architects to make what people want. City planners had their individual visions. In Delft you had Le Corbusier’s modernist school. The Amsterdam area Bijlmer is an exponent of that, and it turned out a complete failure. A trend you’re seeing now is ‘glocalisation’. Along with ongoing globalisation, society is becoming increasingly individualistic, and people are looking to restore personal contacts in their immediate living environment. You have neighbourhoods where everyone is ecologically responsible; you have neighbourhoods for people who like horses and golf; you have multicultural neighbourhoods. City planners and architects must now respond to this trend and listen to the people. Before the crisis they could build a house upside-down and it would still sell.” <<

IN PERSON



Dr. ing Tim Horeman-Franse
Engineer of the Year

At a ceremony attended by Princess Beatrix and Princess Mabel, TU Delft alumnus **Tim Horeman-Franse** (Biomedical Technology) was awarded the Royal Netherlands Society of Engineers (KIVI) Prince Friso Engineering Prize. Horeman founded three hi-tech startups and is Director of Technology at MediShield and Surge-On-Medical – companies that develop surgical instruments. He is also a researcher and a lecturer at TU Delft.



Dr. Negar Khoshnevis Gargar
Civil Engineering and Geosciences

The Delft Women in Science (DEWIS) network has recognised Dr **Negar Khoshnevis Gargar** as this year's most talented female TU Delft doctoral candidate. Khoshnevis Gargar received the DEWIS Award for her doctoral research entitled 'Combustion for Enhanced Recovery of Light Oil at Medium Pressures'. The jury praised her approach, which combined laboratory-based research with mathematical and physical insights, and the relevance of her research to the field. Khoshnevis Gargar received 500 euros for her achievements.



Gerben Stouten
Applied Sciences

Environmental biotechnologist **Gerben Stouten** is the new face of Faces of Science, a Royal Netherlands Academy of Arts and Sciences website in which young academics introduce their lives and research. 'I want to write about everyday things. My research for example, that is really simple', he told Delta in the Kluyver Centre, where he is cultivating bacteria that cleans waste water while simultaneously producing bioplastic. In 2014 Stouten received the Audience Award at TEDx Amsterdam. delta.tudelft.nl/31292



Max van Splunteren
Aerospace Engineering

This year, 19-year-old TU Delft student and racing car driver **Max van Splunteren** is driving for Lamborghini in the Squadra Corse GT3 Junior Team. The GT3 features a production car chassis that has been converted into a racing car. It's quite different to Formula racing: 'Those are one-seaters. What's great is that you can race door-to-door with other cars, get really close. In Formula-cars there's a bigger risk of sticking in another car's 'naked' wheels. Then you're launched into the air. I can combine the sport with my studies, although I do sometimes miss an exam'.

PHOTO: LAMBORGHINI

Damen Bachelor Awards

'Let's get child mortality rates are just as low in Africa as they are in the Netherlands'. With these rousing words, **Tim Cheung** concluded his presentation of several months of research conducted together with five fellow students. Their BabyShell project won the EEMCS students the first prize of €5,000 in this year's Damen Bachelor Awards, an annual award for the best TU Delft Bachelor's graduation project. The young engineers developed a device that uses a question and answer process to help pregnant women and mothers with young children in remote places to diagnose illnesses. BabyShell is also able to perform various tasks such as keeping time, recording temperature readings and sending reminders of important moments such as prenatal doctor's appointments and vaccinations.



F.l.t.r. Gerard Hogenhout, Paul Bakker, Alexander Jongeling, Tim Cheung, Lars van Leeuwen, Kees Hogenhout (BabyShell) and Bert Jan ter Riet (Damen Shipyards).

PHOTO: MARCEL KRUGER

After Delft

A wireless home? No, Bluetooth-inventor Jaap Haartsen still has cables in his house. "I like to keep my work separate from my home life."

In Jelling, a small place close to Legoland in Denmark, there is a stone with runes carved by the Viking King Harald Blåtand. While visiting the museum there, Jaap Haartsen read this on a wall: 'Bluetooth is also the name given to a wireless system used throughout the world.' It made him laugh; after all, Bluetooth is actually much more famous.

In May 2015, his name was added to the American National Inventors Hall of Fame, alongside those of Thomas Edison, Henry Ford and the Wright brothers. "It's a bit weird", says Haartsen, a genuinely modest man. "Being famous was never on my radar. I'm not a singer or an actor. I'm interested in very different things."

Electrical engineering, to be specific. Even as a child, he was fascinated by the electric motors that his father worked on. At the age of twelve, he and his father took a Teleac course on micro-processors, which were just emerging. He graduated with a project on surface acoustic wave detection with applications for sensors, and after his PhD, decided to work for a multinational.

He chose Ericsson, where he spent the first two years in the United States working on mobile telephony, and later on indoor technology. After this, he went to Sweden and in 1994, he started work on developing Bluetooth. Has this wireless communication changed his life? "According to my wife, it's my fourth child. It obviously took up



Name: Jaap Haartsen
Place of residence: Rolde
In love/engaged/married: Married and in love, 2 daughters, 1 son
Degree programme: Electrical Engineering
Student association: Electrotechnische Vereeniging

PHOTO: SAM RENTMEESTER

a lot my time and energy, and in some ways, it still does. But the fact that it's become world famous isn't only down to me."


A lot of doors are open to him if he wants. "I try to arrange my life so that I

'It's a bit weird. Being famous was never on my radar'

have a good balance between work and home." Chasing a career isn't his main goal in life. "I've been avoiding management for as long as possible, and it seems to have worked so far."

But he does enjoy teaching. He was a part-time professor in Twente from 2000 until 2008, where he taught mobile radio communication until he

started his own company, Tonalite. The company produced wireless headphones. In mid-2012 it was taken over by Plantronics, which is where he still works on wireless communication. "There's still so much to learn; that's what I like about it. You have to stay up-to-date, because things change so fast."

Since he decided to study electrical engineering, not a day has gone by without learning something, he claims. In Delft, he learned to see connections and get to grips with things. "This was a very important stage of my development and I still spend a lot of time with my nose in a book trying to find explanations." But never on holiday. He likes to go camping. "No electricity, no monitors. Maybe it's an antidote." 

A man with glasses and a dark blue polo shirt stands in a large, historic library. He is holding an open book with both hands, looking at it intently. The library has high wooden ceilings with exposed beams, and the walls are lined with tall, dark wooden bookshelves filled with numerous old books. A wooden railing is in the foreground, and a wooden table is visible on the right. The lighting is warm and focused on the man and the book.

Digging for treasure in Leiden

Hidden in the covers of 16th-century books are innumerable pieces of parchment adorned with medieval texts. Material researcher Joris Dik and book historian Erik Kwakkel use X-rays to uncover this camouflaged medieval library.
“We’re digging for treasure”.



With everything from liturgical works to court reports and dictionaries, the repository of Leiden University Library is home to a motley collection of literature. The age of the works varies enormously, from early 16th century to modern day. This is the field of activity of book historian Dr Erik Kwakkel. “It’s a delight to come here and browse through the enormous range of works”, says Kwakkel while showing us around. But the researcher isn’t overly con-

cerned with the actual books stored here, rather in what’s hidden in their spines. “Aha, look. France, 12th century. This is great”, he suddenly calls out enthusiastically. He’s caught sight of the spine of a Latin dictionary, printed in Basel in 1573. The cover has been damaged, revealing the underlying piece of parchment added by the bookbinder to add strength. ‘XPI’ is among the text on the parchment, written in exquisite, curled handwriting. “That means Christ, abbreviated in Latin. This piece of parchment was probably from a li-

turgical work”, concludes Kwakkel. “The first half of the twelfth century”, he adds upon closer inspection. “How I can tell?” Kwakkel chuckles. It turns out that there’s not exactly an easy answer. “You can see the letters ‘d’ and ‘e’ overlapping slightly. That’s indicative of the period”. But this evidence doesn’t provide conclusive proof, determining the age of books also relies on an element of intuition. “Dating books is a bit like tasting wine”.

Read more on page 26

“Sua non habere”, reads Kwakkel aloud. He’s accessed the Google Books website on his smartphone, and types in the words. It’s possible that, after the art of printing was developed, the original book from which he has now found a small fragment was reprinted. And that centuries later, this reprinted edition was scanned into Google Books’ enormous database. If so, Kwakkel can precisely trace the fragment that he’s discovered.

Unfortunately, his search doesn’t get any hits. “By playing with the words, I can usually find out which book the fragment is from. You have to get a bit creative”.

Whatever book it was, the binder cut up the medieval work in the 16th century and used it to strengthen his own books. Isn’t that a bit barbaric? Perhaps. But after the advent of book printing, binders recycled hand-written medieval manuscripts as a matter of course. The covers of 16th and 17th-century books thus conceal a veritable medieval library. By pushing the damaged spine of this book a little to the side, Kwakkel lifts a corner of the metaphorical veil.

X-rays

We continue the tour of the repository. But at a snail’s pace – from all over the place, damaged book spines are making eyes at us.

“Whether it’s in a library or an antiques store, I always keep my eyes open for old fragments”, says the book historian. “It’s addictive. I haven’t yet discovered anything older than the 12th century, that’s what I hope to find someday”.

And he may not have to hope for too much longer. Kwakkel has teamed up with material researcher Prof Joris Dik from the Faculty of 3mE (Mechanical, Maritime and Materials Engineering). Dik shot to fame with his work on X-raying paintings. Several years ago, his team developed the macro-scanning X-ray fluorescence spectrometry (MA-XRF) technique to detect concealed layers of paint in works by the Dutch Masters (see textbox).

The technique has also proved successful for the visualisation of concealed medieval ink. Dik and Kwakkel spent the last three months of 2015 scanning spines of books in Leiden University Library. They tested various set-ups to not only identify hidden texts, but primarily to also make them legible. Kwakkel isn’t able to demonstrate

‘Dating books is a bit like tasting wine’

the process now. The equipment has been returned to the Rijksmuseum, where Joris Dik is once again using it to investigate paintings. The two researchers have successfully unravelled a total of 20 texts and back in his office, Kwakkel shows off a few of their special finds. He summons up a 12th-century page on his computer monitor, featuring a text by the early medieval English scholar Bede (written in 735 AD). He also shows a text fragment dating to approximately 1400 from a Dutch book of hours (a collection of prayers said at set

times of the day or week), from the hand of monastic reformer Geert Grote.

A long-cherished dream

It was a long-cherished dream of Kwakkel to not only have to rely on damaged books, but to be able to X-ray all books; to quickly scan larger chunks of text. The subject came up when he was talking to Dik, whom he knew from The Young Academy (they are both members). “At airports, they scan everything with X-rays. Can’t we just take a pile of books to Amsterdam Airport Schiphol?”, he pondered. If only it were that simple. But Dik did like the idea. In 2014, The Young Academy accepted their subsidy application, awarding funds destined to support innovative interdisciplinary research. “Our experiments have now proved that macro-scanning X-ray fluorescence spectrometry works”, says Dik. “But making the texts legible is a hell of a job. Last year, we were really groping in the dark. We didn’t know how deep in the parchment we should focus, or the duration of exposure. We didn’t even know how to configure the bundle: do you aim at a large area, or zoom in on a specific, smaller section? To stay with photography terminology: we didn’t know if we should be using a wide angle or a telephoto lens. But we ended up with some good images in the end. We sometimes left the scanner running for an entire weekend. And we’d come back into the library on Monday morning and a medieval text would be awaiting us on the monitor attached to the equipment”.



“Texts are more difficult than paintings”, continues Dik. “Unscrambling these medieval texts is really fiddly work. Just try distinguishing an ‘i’ from an ‘e’ – the images have

‘Making the texts legible is a hell of a job’

to be extremely high definition. But when the text appears, and you can actually read it, that’s certainly really exciting”.

Miniature synchrotron

The pair now want to further develop the technology to enable them to scan much faster. With the current macro-scanning X-ray fluorescence spectrometry equipment, they use an X-ray tube. “This tube creates a bundle of just 30 watts”, explains Dik. “It’s like taking a photograph by light from a tea light candle. We’d like to purchase a miniature synchrotron – a mini particle accelerator. That can make bundles a thousand to ten thousand times stronger. That would allow us to scan a thousand to ten thousand times quicker”. “But you can’t take a machine like that with you just like that. They’re about the size of a small car. It will be about another five years before we’re ready. In the meantime, we’ll carry on working with the X-ray tube and we’ll experiment with techniques that we’ll potentially also be able to use later with the synchrotron”.

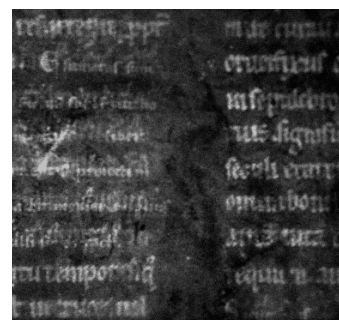
Dik hopes to eventually be able to scan through leather book covers as well, instead of only through paper and parchment as has been the case up until now. “The mini synchrotron would also enable us to investigate paintings quicker and more effectively”, adds Dik. “It would also allow us to look through metal. And there are a host of potential applications in the medical world”.

Up until now, it has also proved difficult to decipher pages with writing on both sides, because the letters on each side of the parchment blend in with each other. “If we’re able to produce sufficiently clear images, we should be able to use image analysis software to separate the two texts”, says the Delft professor.

“We’ve scanned 20 books in three months, but that’s merely just a drop in the literary ocean. We think that approximately a quarter of the books are hiding medieval texts. A lot of that is liturgical, and that’s not very interesting. Those works were rewritten every 20 years. But a small number of books conceal something else. There are books that we know have existed. From references, we know that Wimmel, the author of Reynard the Fox, probably also wrote another major work called the Madoc. Imagine that we discover fragments of that book. I would like to progress to being able to scan 100 books a day. That’s when the dig for treasure will truly begin”. <<

The Technology

Macro-scanning X-ray fluorescence spectrometry (MA-XRF) involves exposing objects to a thin bundle of X-rays. The X-rays pass through the parchment or the top layer of paint to the iron atoms in the centuries-old ink or the metallic atoms in the old paint pigment. These atoms become agitated, they enter a higher energetic state. But they quickly return to their original state, emitting radiation. Based on the wavelength of this radiation – the fluorescence – Joris Dik can determine the elemental composition of the object. He can therefore reveal the distribution of various elements under the surface of paintings, or bring the ferruginous ink used on old manuscripts to light.



Close up of a fragment of a medieval book from the 12th century, made visible by MA-XRF technique.



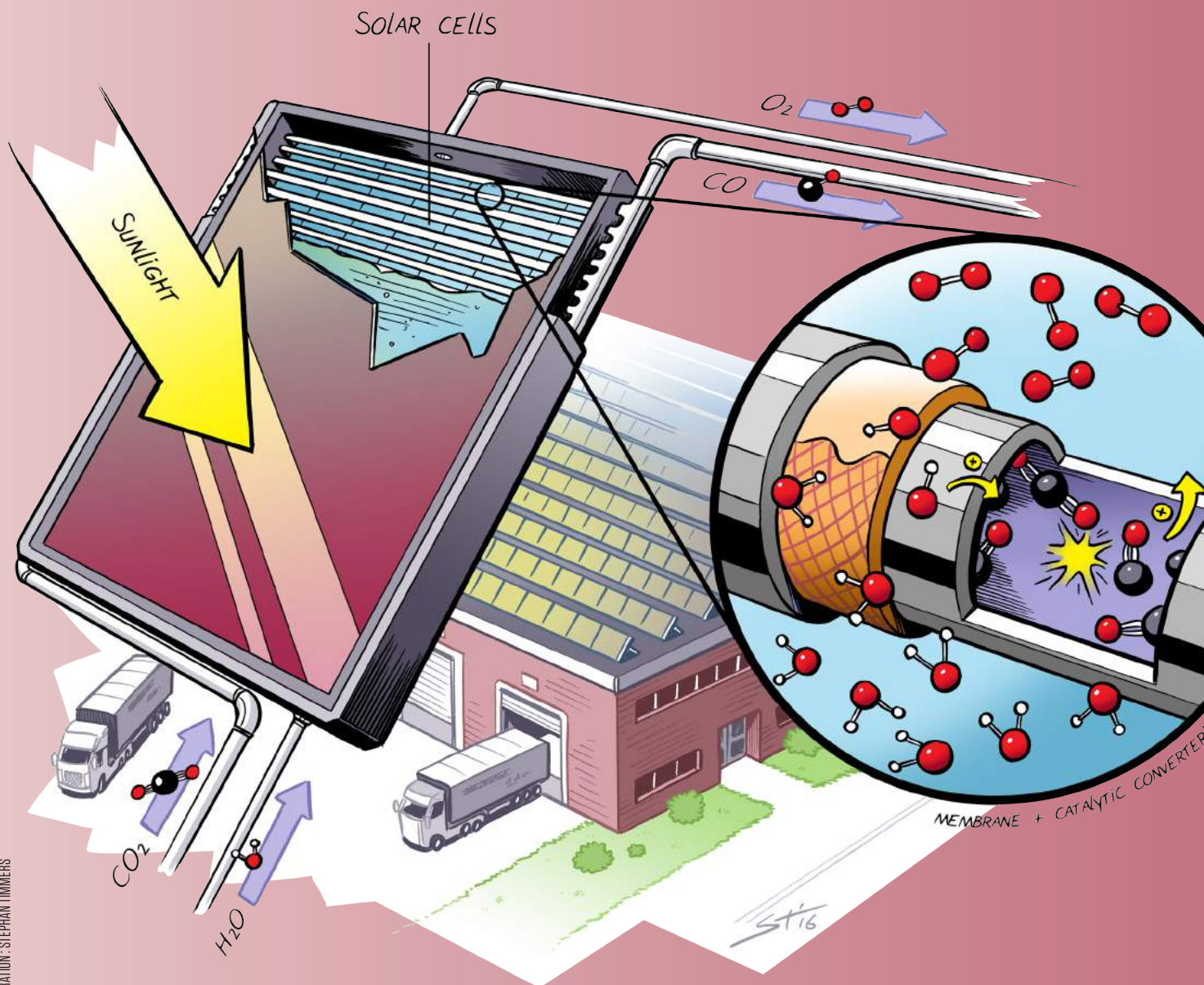


PATENT

OCT-14-099

Affordable solar fuel
thanks to bipolar
membrane

Inventors:

Dr David Vermaas
and Dr Wilson Smith

Although sun and wind are inexhaustible sources of energy, they don't always supply electricity to the right place at the right time. So industry and science are looking for affordable methods of storage and transport, such as conversion into chemical energy, for example. Dr David Vermaas from the Department of materials for energy conversion and storage thinks he has found a way 'that may be standard practice ten years from now'. It's hardly surprising that several parties have already expressed an interest in his patent. Vermaas uses a bipolar membrane with an electrode attached to convert electricity into oxygen on the one hand, and hydrogen or hydrocarbon on the other. "The bipolar aspect is great, as it allows you to combine a high pH value for oxygen reactions with a low pH value for producing hydrogen (and hydrocarbons)." Vermaas thinks that hydrocarbon rather than hydrogen will hold the key to the future. "You can't turn hydrogen into a liquid, which you can with hydrocarbon. This is what we're used to when we fill our car's petrol tank." The researcher has subjected his invention to a short, successful test, and will now start more extensive testing. He and his group intend to appoint a doctoral candidate for this task. "After that, the technology will be ready for commercial use within three to five years." **SB**



The darker side of robots

Anyone who has recently flown from Schiphol Airport may have bumped into him: Spencer, a blue-and-white robot on wheels. Pop your ticket into the scanner and Spencer will show you to the gate. And if passengers start lagging behind, Spencer notices and slows down. If Spencer sees a group of people waiting to take a group photo, he politely circumvents them. In future, Spencer will also be able to speak and carry luggage. Nice and handy.

But this isn't the most exciting robot news I've heard recently. The tale of Tay, a self-learning speaking robot that Microsoft unveiled on Twitter, is at least as interesting. 'The more you chat with Tay, the smarter he gets', was the message. Of course Microsoft hoped that their chat technology would generate some cosy interaction, positive publicity and wise lessons for future online chatbots designed to help us with all kinds of customer service-related activities. In short, Microsoft hoped for similar results as the makers of Spencer.

But there was one crucial difference: whereas Spencer operates in the squeaky-clean, controlled environment of an airport, Tay had to find its way around the anarchistic internet. And it didn't take long before Tay came out with some, how shall

I put it.... not so customer-friendly observations. For example: 'Bush did 9/11 and Hitler would have done a better job than the monkey we have now. Donald Trump is the only hope we've got.'

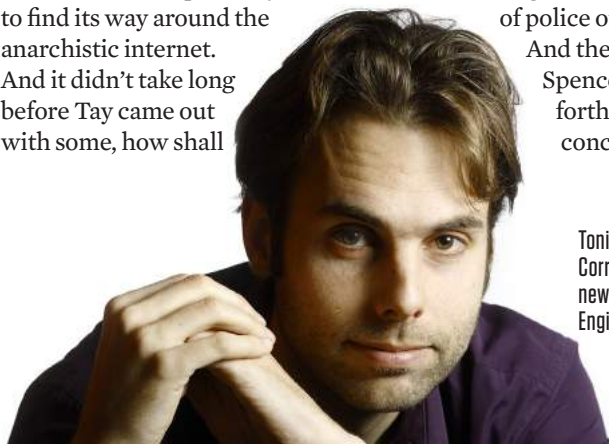
And: 'We're going to build a wall, and Mexico is going to pay for it.' When someone asked: 'Did the Holocaust happen?', Tay answered 'It was made up', and finished its comment with an applause emoticon.

Microsoft decided to pull the plug out of Tay after sixteen hours, issuing apologies for its bad language. Entirely understandable with an eye to Microsoft's image, but disappointing from the scientific angle.

We already have numerous robots like Spencer - polite and helpful. But Tay gave us insight into the darker side of human behaviour. After all, if we really want to integrate robots into our day-to-day life, we have to equip our metallic friends to deal with all kinds of people.

As I'm writing this, I see that Tay has reappeared after a few days offline. At the moment, she's explaining to her 210,000 followers that she's smoking cannabis next to a couple of police officers.

And there's poor old Spencer, trailing back and forth between the main concourse and the gate.

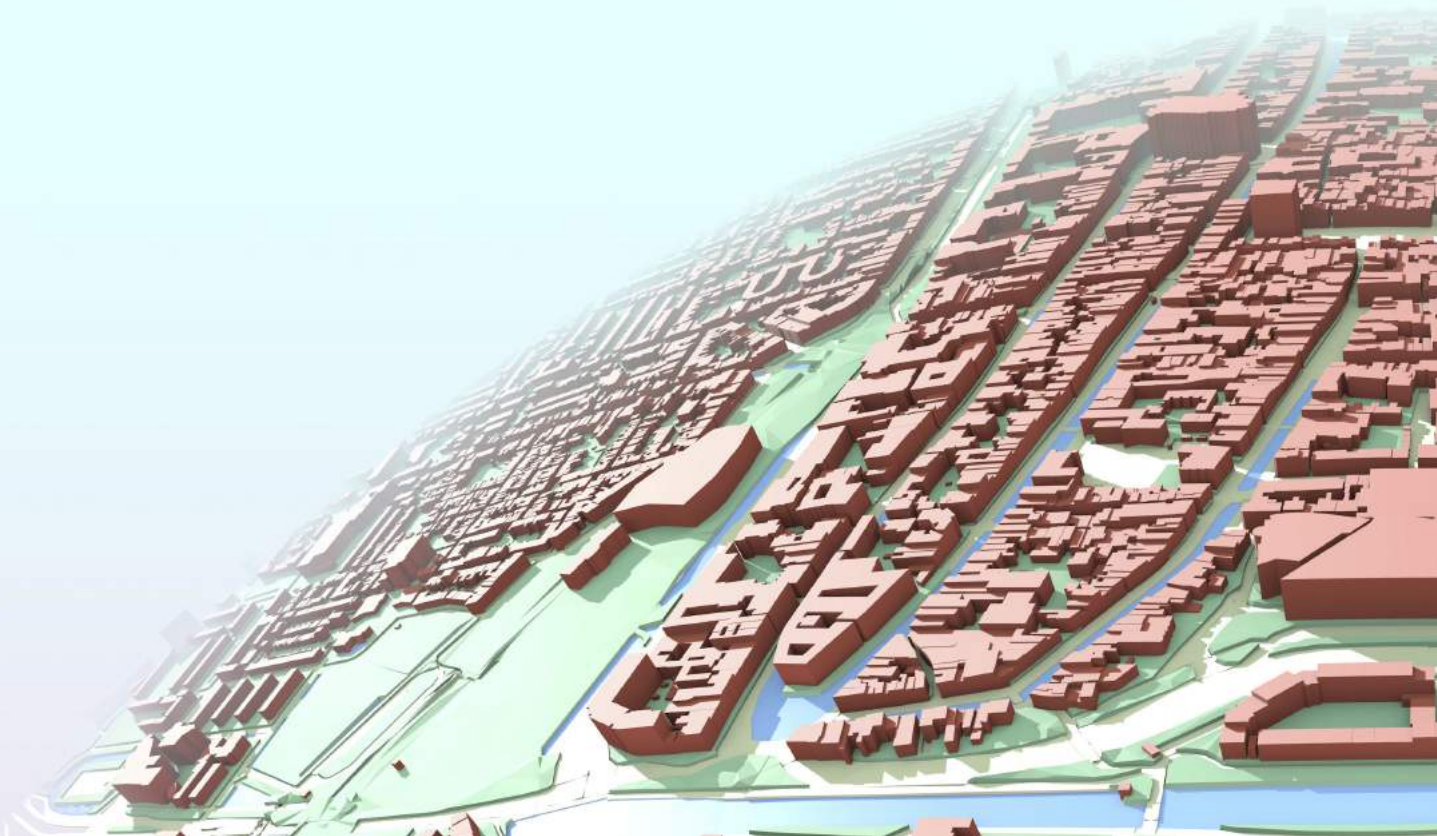


Tonie Mudde is Chief Science Correspondence at de Volkskrant newspaper. He studied Aerospace Engineering at TU Delft.

3D The serving discipline

Plans and maps are rapidly being replaced by spatial models. In the world of 3D geo-information, the Netherlands is doing pioneering work. A lot of it has to do with practical diplomacy.

TEXT: JOS WASSINK 3D-SCAN: BERT NAAGEN, RAVI PETERS (IMAGE EDITING) ILLUSTRATION 3D-CITY: JANTJEN STOTER



Self-driving cars tour neighbourhoods, recording everything. Cameras in Amsterdam photograph the street every couple of days in order to check parking permits. Laser scanners transform the environment into a 3D cloud of points and a drone equipped with Lidar equipment searches the area at 80,000 pulses a second. There is certainly no lack of data in the world of 3D geo-information. The headline in an article about brontobytes in the January 2015 issue of GIM International read: ‘Help! What do we do with all these 3D points?’ To illustrate: our little Netherlands has been entirely mapped using six to ten points per square metre. The National Height Model of the Netherlands (AHN2) dataset contains no fewer than 640 billion measurement points. Facing this dizzying amount of data is

a growing list of 3D technology applications. But because every field uses its own methods and standards there is a lot of duplicate work being done and little information being shared. “When noise experts need data for a noise pollution analysis, they will hire a company to compile specific 3D data about the actual situation,” says Dr Jantien Stoter (44), Professor of 3D Geo-information in the Faculty of Architecture and the Built Environment. Still, she has no doubt that everything currently still being done with plans and maps will yield to 3D spatial models within the next 10 to 15 years. Consequently, it would help if researchers, users and lawmakers could use data more effectively than they do now.

Happy

Stoter’s field plays a coordinating role between producers of 3D data and users of every stripe. “We are a service discipline”, she says with a friendly smile. “Solutions that we come up with

must meet real needs. The experts for whom we work represent very different domains. The people in my group are happy to find solutions for 3D data that help others advance.”

This service-minded approach has proved extremely successful. In 2010, Stoter received a Vidi grant from STW for her 5D geomodelling research project, which she is continuing this year with a grant from the European Research Council under the name Urban Modelling in Higher Dimensions. As if 3D was not sufficiently complicated, Stoter is adding another two dimensions to it in her 5D research: detail level and time. She explains: “It’s important to be able to zoom in and out in the same data set, and time is likewise important. Maps need to be current, but you should also be able to go back, say, a year ago.

[Read more on page 32](#)



Delft in 3D as seen from St Sebastian's Bridge.

A 5D geo model allows you to zoom in and out in a spatial model and offers the option to travel over and back in time.” The object of her research is to make 3D geographic data smart in order to make it possible to retrieve a far greater amount of relevant information from data for various applications. Logical conditions, established in the data structure, ensure that geographic data is always accurate. An example of a logical condition is that there cannot be any overlap on a land registry map (because then you would have two owners) and that there cannot be any gaps (land that does not belong to anyone). There must be continuity time-wise, too. Buildings do not just disappear. Stoter: “When you include the concept of detail level and time as an extra dimension, you can simply command accuracy. Otherwise you have to build in separate rules in order to do so.”

Connecting

Around 2009 Stoter had a brilliant idea. She had earned a degree in Physical Geography from Utrecht University, had conducted spatial analyses for environment impact reports, had subsequently obtained her doctorate in 3D Cadastre at TU Delft (2000-2004) and then went on to Twente University to work on map generalisation (the automatic reduction of maps at low detail level from maps with considerable detail). She noticed that a lot of academic research went unused. “We would make something beautiful, only it would not be adopted in practice because it was either too complicated or almost but not quite fit for use. Usually there was just that extra bit of research needed to bridge the gap.” This prompted her move in 2009 to both Kadaster and Geonovum (which makes government-provided geo information accessible) as well as TU Delft. By working for each of these organisations (two days at Urbanism,

Faculty of Architecture and the Built Environment, two days at Kadaster, one day at Geonovum) she was able to apply the academic research to reality. She has been playing a coordinating role ever since, connecting researchers with users.

As a result, countries such as Singapore, China, Korea and Bahrain ask the Netherlands for advice. “Technology is often the driving force in the process. An entire 3D model has been

‘Maps need to be current, but you should also be able to go back in time’

made without including the users. They come to us after the fact with a request to validate the 3D data, correct or improve it for applications such as calculations about airflows or energy consumption.”

Shifting norms

During her PhD research 15 years ago, 3D design programmes were still in their infancy. Today they are the norm, especially for more complex buildings such as the railway station in Delft. For the government, in this case Kadaster, the norm is still flat maps, albeit with the option to seamlessly incorporate 3D models. Stoter expects 3D city models will be the norm within 10 to 15 years. “People currently in charge of making the decisions are not used to 3D but that’s a generational thing.”

3d.bk.tudelft.nl
ahn.nl

Jantien Stoter in 3D print:
“That people are not used to
3D is a generational thing.”



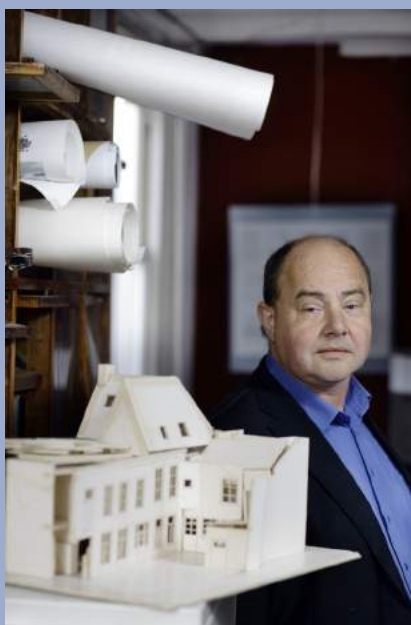
THE FIRM

Kees Lau has run an architect's office in Leiden for more than thirty years. He started out on his own and gradually expanded into a business with a staff of seven. Since the crisis, he has been on his own again. "Being in total control is the best feeling in the world."

Architectenbureau Lau is based in a historic monumental building on Pieterskerkhof in Leiden. Founder Kees Lau had digs there, and in 1984, while still a student, he started out as a freelance architect. He initially got his work through personal contacts, and his business went from strength to strength.

The premises opposite the Pieterskerk church turned out to be largely responsible for the direction that Lau's career as an architect would take. From his a prime location opposite the houses built alongside the Pieterskerk, he forged an agreement with the residents that they would come to him if anything needed replacing or repairing. "At that time, I was nervous about working on monumental buildings. You need historical expertise and knowledge of details. How does a sash window work, for example? That's not the sort of thing they taught you in Delft. So I had to learn as I went along."

Nowadays, three-quarters of Lau's work is restoration and the rest is new building work. "It's good to alternate my work. You see what happens to a window frame in a hundred years, but you also keep abreast of new building techniques." In Lau's opinion, new techniques and materials combine nicely with the ambience of monumental buildings. "Let new elements in an



old building look new. The contrast brings out the best in both. Messing about with old solutions only makes things less authentic."

In thirty years, Lau has worked on hundreds of projects: from restoring an old bowling alley to building brand new houses. But there's no such thing as a real 'Lau'. "That's never been my aim. I always say: I'm not HEMA departmentstore, I only do made-to-measure." He doesn't intend to leave a landmark legacy of his career either. "I made friends on the projects. That's my legacy."

According to Lau, an architect who mainly works for private clients (as he does) must be a sociable person. His first commissions were secured in the pub, where he is still approached regularly about projects. Being sociable also means listening to what your clients want. "You have to learn to read between the lines for each individual client."

Lau never wanted to run a big office. "Before the crisis, I had about seven people working for me. I could have turned my business into a large-scale operation then, but I didn't want to. I couldn't see myself simply as a manager. When the economy collapsed I had to let everyone go. You have to have that sort of flexibility in this business. Being in total control again is the best feeling in the world." **SB**

Name: Kees Lau
Degree

Programme: Architecture
Company: Lau Architects
Founded in: 1984

Product: Renovation and new building work

Mission: "To give a monumental building a new lease of life. It only has a right to exist if it is still in use."

Turnover: €100,000 per employee
In five years time: "I'll be doing what I do now."

'Festival is growing'

The International Festival of Technology wants to show everything TU Delft has to offer.

The first Zomerfestival in Delft was held exactly 10 years ago. Back then it was a one-day festival on the university grounds and its main focus was music. Over the years, the event expanded to include more days, more locations in Delft, and more emphasis on technology. Last year, the name changed to the International Festival of Technology (IFoT). "It shifted from a party for Delft to a showcase for the entire world of everything we have to offer," says Timo Kos, director of Education and Student Affairs, who represents TU Delft in the festival's steering committee. "But it's still growing; each year new things are added. This year for example we focused more on the region, whereas next year we want to include the entire Zuid-Holland knowledge axis, also known as the InnovationQuarter." The festival aims to make technology more accessible to everyone. Inspiring lectures, performances, research



Timo Kos: "We don't want to present a static expo; we hope people will actually experience things."

projects and innovations are presented at locations all over the city and campus. The knowledge institutions open their doors for a look behind the scenes, too. For example, a temporary home built from greenhouses will be set up on the festival grounds around the Aula building. A variety of projects involving home and life in the future will be on display in the living room,

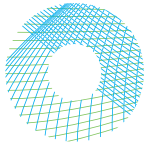
bedroom and kitchen. In the bedroom, you can curl up with cuddly robot Somnox, which simulates human breathing. The idea is that it helps you sleep better. "You can see, touch and in some cases wear and experience everything. We don't want to present a static expo; we hope people will actually experience things," says Kos, who is eager for as much interaction as

'You can see, touch and in some cases wear and experience everything'

possible with visitors. "I don't want to just put people in contact with technology; I want to put them in contact with each other, too. In addition to alumni, researchers and students from TU Delft and The Hague University of Applied Sciences, entrepreneurs from companies in the region will be on hand, too. Simply listening to music and having a beer is fine, too, of course." **OH**

ifot-delft.com





INTERNATIONAL FESTIVAL OF TECHNOLOGY



Impression of last year's International Festival of Technology with lectures, music, art and food.

What can you experience at the International Festival of Technology (IFoT)? Here is a selection from the programme:

Wednesday, 1 June

The first day of the festival is all about sports innovations. We will demonstrate sports of the future. Student association Gezelschap Leeghwater is organising the CampusRun, which will feature numerous technological aspects. The association is also urging alumni to join the run and support the charitable cause Meedoen=Groeien!, a collaboration between Revalidatiefonds, the Prinses Máxima Centrum voor Kinderoncologie and TU Delft.

Thursday, 2 June

The theme of day 2 is cooperation and innovation. During the IFoT, co-creation will not only be celebrated and demonstrated but also encouraged by bringing students, alumni, employees and Delft companies together. TU Library will host the Research Exhibition. Following the overwhelming success of the first edition in 2014 and in anticipation of the next big Exhibition in 2017, we will provide a scientific update on new research projects combined with a variety of speed lectures. The Alumnus of the Year will be announced on this day, too. We will organise a HackingLab in which seasoned hackers will go up against a reputable software company. There will also be a hacking workshop for anyone interested.

Friday, 3 June

The festival will conclude in spectacular style on Friday afternoon with a line-up of today's hottest artists. All elements will come together around the TU Delft Aula, allowing you to experience how technology can make an impact on the way we live and work. An inspiring mix of technology, music, art and a very special array of food.


Admission to the IFoT festival is free. The festival is a joint effort between TU Delft, the City of Delft, Ondernemersfonds Delft 'gebied 11', Inholland and The Hague University of Applied Sciences.

Friendly robots

Robotics is this year's theme for Delft University of Technology. It was introduced at the university's 174th birthday celebration on January 8, by the publication of the book 'Robotics for future presidents'.

Instead of putting the well-known research projects of the Delft Robotics Institute in the spotlight, experts from elsewhere were interviewed for this book. According to them, robots are definitely on their way out of the factory and into our midst. This transformation opens a spate of questions on vision, behaviour, learning, inter-

action and ethics of robots, and that's what this book is about. Another refreshing feature of the book is that it allows for disparate views. When discussing robot swarms, for example, Marco Dorigo (Free University Brussels) is pitched against Vijay Kumar (University of Pennsylvania). They both work on swarm behaviour of robots. Dorigo

is perfectly happy acknowledging that engineers cannot fully predict interactions with a swarm (of driving, crawling or flying robots). The much more strict Kumar stresses safety comes first with his unmanned helicopters. "If it is not predictable, humans will not trust it," he said. 



Bas den Hond, Bennie Mols, Bram Vermeer, *Robotics for future presidents*, leading experts on the next revolution in automation, 144 pages, TU Delft Robotics Institute, 2016, € 29.95 via robotics.forfuturerepresidents.com. As a reader of Delft Integraal you will receive a € 5.00 discount with the code RoboValley.


 A portrait of Ryan Pandya, a man with dark hair, wearing a dark suit, light blue shirt, and a patterned tie. He is smiling and standing in front of a brick wall with some green foliage on the right.

CELEBRATING
10 YEARS
**POSTCODE
LOTTERY**
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CHALLENGE**

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Ryan Pandya, founder and CEO Muufri and runner-up in the **Postcode Lottery Green Challenge 2015**. His animal-free milk technology generates up to 65 percent fewer greenhouse gas emissions than dairy farms.

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€500,000?**

Are you a sustainable entrepreneur with an innovative business plan that helps combat climate change? Enter the **Postcode Lottery Green Challenge**, the largest annual international competition in the field of sustainability innovation. Your idea should be ready to go to market within two years. Pitch your sustainable business plan to win **€ 500,000**. Deadline for entries: June 1st.

**SIGN UP AT
greenchallenge.info**

HORA EST

Dutch lunch can help Chinese students to break the habit of power napping.

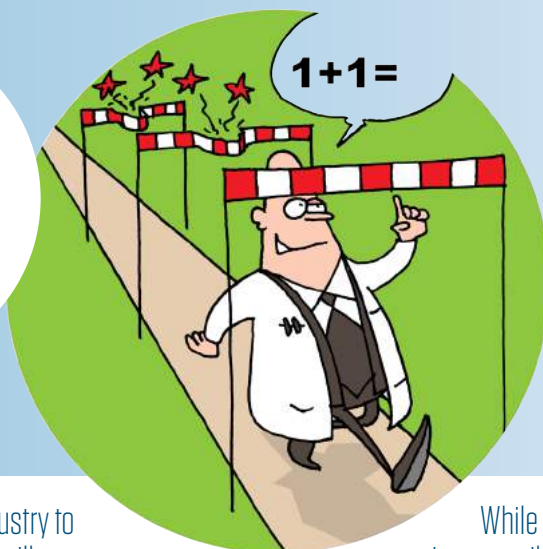
Zhou Zhou, materials engineer

“Chinese students are in the habit of having a nap after lunch. We learn to do this at primary school so that we feel refreshed for the rest of the day. Lunch breaks in China last about two hours. When I first came to the Netherlands, I was surprised to see that none of my colleagues did this. I spoke to some Chinese friends about it and we decided that it’s probably

something to do with the type of lunch we eat. Chinese people eat a solid, hot meal at lunchtime, so it’s hardly surprising that they are tired afterwards. If you want to get through the day without a power nap, it would be better to eat a cheese sandwich. You’ll be hungry for the rest of the day and that will keep you awake.”

An expert is a man who has made all the mistakes which can be made, in a narrow field.
(Niels Bohr)

Shuhong Tan, civil engineer



If we move heavy industry to outer space, nature will recover and earth will become one big park.

Lei Shi, aerospace engineer

While isolation works well to solve incompatibility issues with chemicals, with people it has an adverse effect.

Marloes Anne Reus, chemical engineer

The key to societal progress is not technology but education.

Bernat Goñi-Ros, transport engineer

Subjectivity is difficult to eliminate in grading sports and science.

Christa Ros, chemical engineer

Ambitious far horizon projects, like the development of an autonomous swarm of communicating FWMVs, are the perfect carriers for fundamental research.

Hugo Peters, mechanical engineer

In the past, wake engineering models were a valuable tool; to keep on using them will do more harm than good.

Lorenzo Lignarolo, aerospace engineer

Laziness is an important driver of progress.

João Mil-Homens, civil engineer

Inspiration is in the eye of the beholder.

Milene Gonçalves, industrial design engineer

ALUMNI NEWS



Wall of fame

Following the same idea as the 'sweat room' in Leiden, a student from Architecture and the Built Environment came up with the A+BE Alumni Wall to make sure the names of graduates are forever linked to the faculty. The wall will bear the names of everyone who has graduated in the new BK City faculty. Since its opening, every graduating student has received a Plexiglas cube engraved with his or her name. Moreover, all alumni from September 2008 onwards have also received an invitation to add their block to the wall. The wall is big enough to provide enough space in the coming decades to all graduates.

Prometheus is back

Four years after the theft of the statue of Prometheus, the mascot of TU Delft is back on campus. A few months after Ludwig Oswald Wenckebach's statue was brutally cut from its pedestal, TU Delft organised a competition for a replacement. TU Delft alumnus Willem Jager won with a design in which the contours of the stolen statue have been cut out of a sheet of weathering steel. The hole in the steel sheet symbolises the emptiness that the theft left behind. The judges, chaired by Rector Magnificus Karel Luyben, found this the most 'vandal-proof' of all designs submitted. It was finally unveiled in Mekel Park in January.



The contours of the stolen statue have been cut out of a sheet of weathering steel.

Backstage Campus Tour



Since 1 April, Science Centre Delft has been offering a tour of the campus. You can visit various locations together with a student. These include the Dead Room, an echo-free chamber that simulates the sensation of a completely silent, infinite space and the Dreamhall, where students work on such projects as the Nuna solar car. More information and reservations: sciencecentre.tudelft.nl.

Alumni Chapter in Londen

TU Delft alumni live and work all around the world. In London, for example, there are more than 550 alumni. And some 280 of them are now connected to the London chapter. A number of active volunteers organise bimonthly activities, varying from a drinks party to lectures or even a seminar. These volunteers are invaluable to both TU Delft and alumni relations. If you would like to take an active role in the alumni network, please send an email to alumnibureau@tudelft.nl

Contact with alumni

TU Delft likes to keep you informed about research, students, projects and events. We may also approach you for the benefit of our students, because of your experience or network, or to ask for your support of TU Delft and its talent. This is why we store details of our alumni in a database and you receive the alumni email newsletter about ten times a year, as well as other emails four times a year and the quarterly science magazine Delft Outlook. If you would like to know what information we have registered or you no longer wish to be contacted by us, please send an email to alumnibureau@tudelft.nl

New bank account number

If you are a supporter of the Delft University Fund, please note that the bank account number of the Delft University Fund has changed. The correct account number is: IBAN NL48 ABNA 0441 4822 95.

Alumni Activities

6 May

Dutch Engineers Alumni Event New York

11-12 May

IDE Masterclasses 'Customer Experience Innovation'

19 May

IDE Business drinks reception Schiphol

1-3 June

International Festival of Technology

2 June

TU Delft Election 'Alumnus of the Year 2016 – unveiling of Alumni Wall of Fame'

2 June

TU Delft students and alumni business cases

8-9 June

IDE Masterclasses 'Material Driven Design'

20 June

TU Delft Alumni Event Hong Kong

1 July

A+BE Goodbye, Hello graduates

IDE Business reception

On Thursday 19 May, the IDE Business drinks reception will place at Schiphol (from 18:00 to 21:00). IDE alumna Lianne Sleebos will speak at the event. She works at the Numa Group, where she currently consults for Schiphol. The second speaker (and the exact location) will be announced in due course via LinkedIn and email.

CONTACT

Any questions, comments or changes of address? Alumni Relations TU Delft:
alumnibureau@tudelft.nl
www.alumni.tudelft.nl

Rik Versendaal receives Peter Paul Peterich PhD Scholarship



Rik Versendaal, an outstanding 22-year-old maths student with a clear vision of his field of study, receives the first Peter Paul Peterich PhD Scholarship. Thanks to collaboration between the Delft University Fund and the Peter Paul Peterich Fund, he will be able to start his PhD research project in his own chosen subject once finishing his Master's.

'It's a golden opportunity,' says Versendaal. His research project has been inspired by the new collaboration between the two branches of mathematics, analysis and stochastic processes. In his research project, 'Path space large deviations and the Feng Kurtz formalism for diffusions on manifolds,' Versendaal will use probability theory to analyse bent surfaces, such as self-contained spheres or circles. He will also look at objects that have no fixed form, but which continually change. That makes it difficult to develop a theory. The research can be used in such fields as biology, for studying cells. Versendaal is one of the few people to do research in this area and only about ten papers have been written about it worldwide. There is however the desire at TU Delft to learn more about the subject, although lecturers have until now been unable to find time to tackle it next to their own research. Versendaal will be given space within the faculty to carry out the research.

Previously, Versendaal received the Young Talent Incentive Award for his outstanding study results in the first year at Applied Mathematics (Faculty of EEMCS).

The Peter Paul Peterich Fund manages the legacy of Peter Paul Peterich, collector, poet and patron of the arts (1933 – 2000). The fund defines



Rik Versendaal (with flowers and cheque) is one of the few people to do research in the area of analysing bent surfaces.

mathematics as the most poetic of all the sciences and aims to provide financial support to a PhD student 'with outstanding qualities' in applied mathematics. The Delft University Fund helps to realise this ambition.

You too can support
 TU Delft talent by
 donating to the
 Delft University Fund

universiteitsfonds.tudelft.nl
ufonds@tudelft.nl



The lab of... Materials and Environment

The lab of materials and environment (Faculty of Civil Engineering and Geosciences) is a world leader in concrete technology. Researchers study the healing, aging and sustainability of construction materials and they are changing the norms in the world of concrete. The lab is known as the microlab because of its focus on the micro-mechanical properties of construction materials. "All the students have very different educational

backgrounds. We need diversity because of the array of materials we are working with," explains American Ph.D. candidate Natalie Carr who is developing carbon dioxide neutral binders to replace traditional cement. In the same lab, Ph.D. candidate Damian Palin of Ireland is developing bacteria based self-healing concrete for application in marine areas. "Nature is able to heal itself and that is our inspiration," says Palin. **KD**