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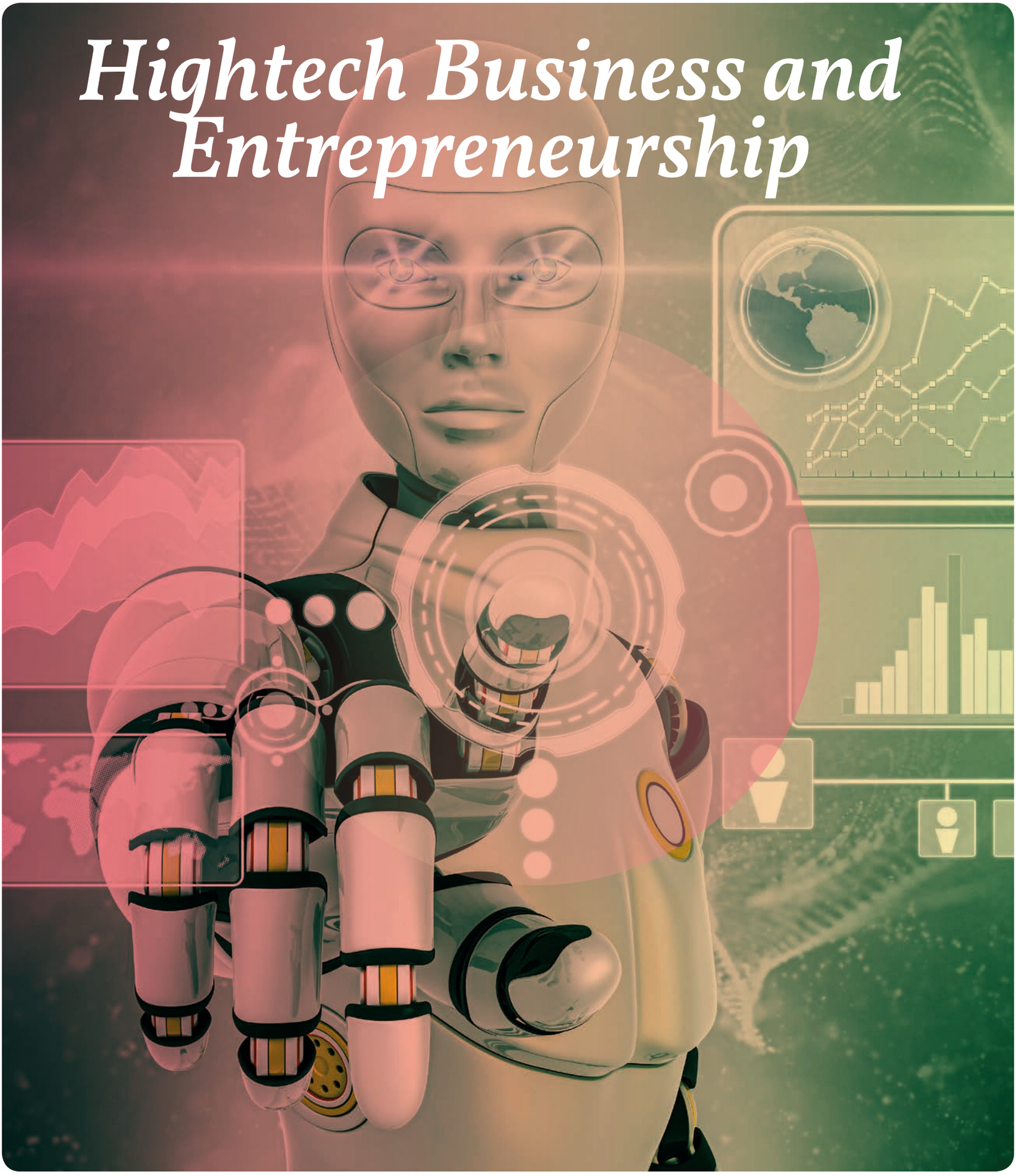
Hightech Business and Entrepreneurship



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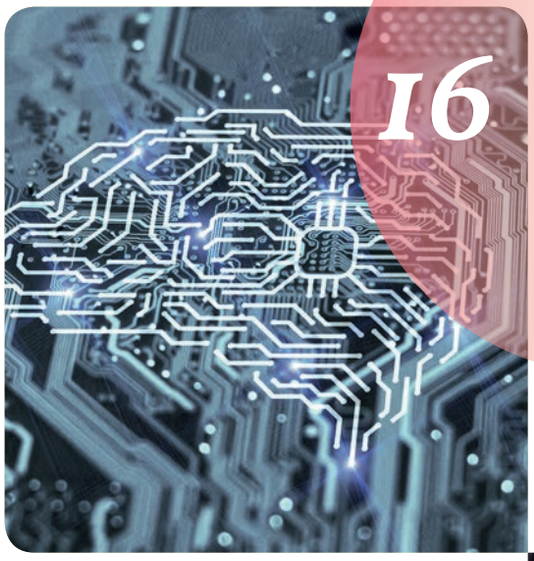

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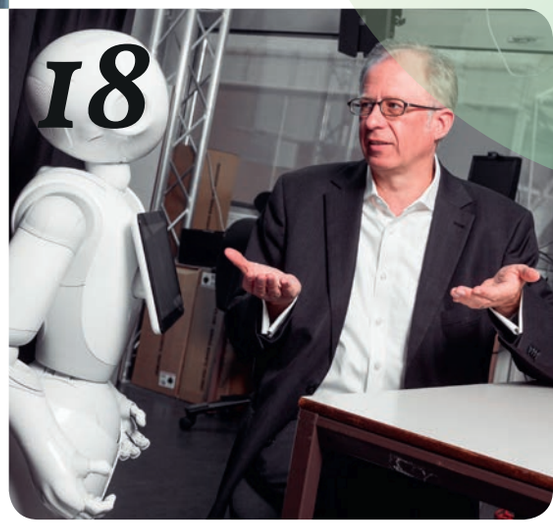

Colophon

This magazine is a special edition by U-Today, an independent journalistic medium at the University of Twente. It was made in close collaboration with the department Hightech Business & Entrepreneurship and coordinator Martijn Mes.

The following people worked on this special:

U-Today: Sandra Pool (coordinator & editor), Michaela Nesvarova (journalist), Maaike Platvoet (editor-in-chief), Rense Kuipers (journalist), Jelle Posthuma (journalist) and Rik Visschedijk (journalist).
Frederike Krommendijk (freelance writer).
Hightech Business & Entrepreneurship: Martijn Mes.
Frans Nikkels (freelance photographer)

Design and realisation:

Jeremiah Wetzel
(SMG-Groep, www.smg-groep.nl)

U-TODAY

Postbus 217, 7500 AE Enschede, The Netherlands
+31(0)53 489 2029, utoday@utwente.nl

www.utoday.nl

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FOREWORD

The brand-new Hightech Business and Entrepreneurship (HBE) department at the Faculty of Behavioural, Management and Social Sciences holds a leading position at the interfaces between business, technology and the social sciences. With this U-Today special, we proudly present ourselves to you while we celebrate more than 50 years of management studies teaching and research at the most entrepreneurial university of the Netherlands. Meet the people behind our innovative research projects and our top-rated educational programmes International Business Administration, Business and IT, Industrial Engineering and Management, and other business and management courses open to all UT students, honours programmes, executive teaching and exchange modules, as well as tailer-made subjects for UT's technical programmes.

HBE researchers conduct highly valued cross-disciplinary business research, supporting organizations in innovative and entrepreneurial management practices and decision-making. This ground-breaking research is applied to various high-tech business domains. More specifically, we study the impact of technological developments on the way we execute our business functions, and how these technologies can be deployed to improve performance.

With this U-Today special issue, we share with you – our students, colleagues, industrial network partners and stakeholders – our passion for high-tech business research and education. We do this through interviews with a diverse group of researchers from the HBE department, spread out over the various research groups within HBE. Topics dealt with in this issue are the history of 50 years of management studies and research at the University of Twente, Entrepreneurship and Innovation, Healthcare Logistics, Smart Industry, AI in Logistics, Machine Learning for Education, and Fintech. Once you get inspired by what we offer, don't hesitate to seek us out – we are always looking for innovative and entrepreneurial new students, collaborations and research challenges in co-creation with you! For now, enjoy reading this special!

Petra de Weerd-Nederhof and Martijn Mes

‘Putting technical knowledge into practice’

Technology has become deeply ingrained into the world of business and modern business administrators have to possess a thorough knowledge of robotics, artificial intelligence and data science. ‘We have everything we need to link technical knowledge to business processes,’ says Jos van Hillegersberg, head of the Hightech Business & Entrepreneurship (HBE) department.

For a long time, business administrators believed there would be no more major developments in their field, Van Hillegersberg says. Of course, the digitalisation of business processes presented some challenges. However, with some knowledge of networks, Microsoft software and SPSS for statistics, business administrators could make do just fine. ‘That time is behind us,’ Van Hillegersberg continues. ‘These past five years, it has become clear just how disruptive technology is. Just look at examples like Apple Pay, Google Flights or the logistics behind Amazon. Businesses must embrace these technological developments or be left in the dust.’

HBE is a new cluster that consists of six departments. Together, they cover a wide range of fields: from finances and human resource management to purchasing, organisational studies, entrepreneurship, information systems and industrial engineering. ‘On top of that, we collaborate closely with the campus’ scientific faculties,’ Van Hillegersberg says. ‘That combination gives us unique knowledge in the field of hightech business and entrepreneurship. We have everything we need to link technical knowledge - e.g. concerning robotics, artificial intelligence and simulations - to business processes.’

The digitalisation of processes

In this age of digital transformation and Industry 4.0, business administrators need that unique knowledge. It not only impacts modern businesses who have embraced the latest technological developments; existing businesses are also pushing hard to digitise their processes. As an example, Van Hillegersberg mentions the multinational organisation Tata Steel, for which HBE conducted a project. ‘The company has to modernise its operations to keep up with the competition. Our students and doctoral candidates were able to retrieve a wealth of information from its production line using data science and neural networking techniques. That information can be used to optimise your processes and determine exactly when and where maintenance is needed.

‘Businesses must embrace these technological developments or be left in the dust’

This is a completely different way of running a business than the traditional method that relies on quarterly figures.’

The maritime sector is another good example. ‘Companies such as Boskalis operate on a global scale. It conducts dredging operations all over the world. A vast quantity of data is produced during that process. With smart algorithms and business administrators who understand how to use that information, the organisation can restructure its global processes to operate in an optimally efficient manner. It can, for example, manage its fleet far more effectively from a central location and draw up a thorough maintenance plan.’

Speaking each other’s language

With the BMS Lab, the UT has the people and the means to truly allow this form of business administration to take flight, Van Hillegersberg says. ‘We took that step with regards to both our research and our education,’ he says. ‘What is unique about the UT is that our business administration students sit in the same lecture halls as, for example, our mechanical engineers and computer scientists. From the very beginning, they all learn to speak each other’s language. They work together in project groups and complete internships with businesses, to ensure we are not just teaching them about the theoretical aspects of the field. Instead, they get to work in a hands-on manner and learn how to spot opportunities and get the work floor excited about these processes.’

There are myriad challenges, Van Hillegersberg says. Data are being generated everywhere, from the healthcare and construction sectors to the worlds of finance and logistics. ‘That is why we are expanding rapidly,’ Van Hillegersberg continues. ‘Over the coming years, we will

INTERVIEW

Text: **Rik Visschedijk**
Photo: **Frans Nikkels**

be hiring quite a few extra people so we can truly substantiate our collaboration with the industrial sector. That benefits the businesses and our department: businesses can give their efficiency a massive boost, while our students get to work with real data. That is much better than having to rely on simulations only.'

A business as a living lab

Van Hillegersberg says this method of using a business as a 'living lab' is truly innovative. 'These past two decades, businesses were largely run based on trends,' he says. 'For example, countless organisations suddenly began adopting the 'lean' method. It is easy to forget that no two businesses are alike and each has its own unique ecosystem.' He continues: 'By using a business as a living lab, you can fine-tune your approach as needed. Having the experts who can distil the right information from that lab saves on high consultancy fees.'

Sustainability

With hightech business and entrepreneurship, businesses are not only optimising their processes; they can also work towards achieving their sustainability targets. 'Personally, I think that is a wonderful aspect,' Van Hillegersberg says. 'The government has mandated it, of course, but more and more businesses also have an intrinsic motivation to operate in a circular manner. With data analysis, businesses can be made more sustainable. Another option is to optimise the process of reusing returned products. The time of companies launching one product on the market and immediately moving on to the next is over. Doing this well and efficiently requires insight into the entire life cycle of your products.' ●

Facts & Figures
about the HBE department

Main research topics

1. sustainable renewal and development of industry, logistics, smart cities, and healthcare
2. support of innovative and entrepreneurial decision-making in private and public organizations
3. innovative business models and organizational forms for circularity and inclusive societies, businesses, and governments
4. computational social sciences for businesses in and beyond the 4th industrial revolution
5. advanced decision support (AI, machine learning, mathematics, big data) to cope with industry disruption by digitalisation.

Total staff 169

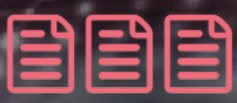
9 FTE full profs

10 FTE associate profs

59 FTE total tenured staff

26 FTE assistant profs

88 PhD students



1197 Publications current staff

Top education

Bachelor IEM
Top in 2019 and 2020

Master IEM
Top in 2018 and 2019
(master 2020 not yet known)

Bachelor IBA
Top in 2020

In the 'Keuzegids Universiteiten' these Top rated study programs had a total score of at least 76 points out of 100, based on the national student survey. This means that the program is amongst the best in the Netherlands.

Research groups

- Industrial Engineering & Business Information Systems (IEBIS)
- Entrepreneurship, Strategy, Innovation and Marketing (ESIM)
- Technology Management and Supply (TM/S)
- Change Management & Organizational Behaviour (CMOB)
- Human Resource Management (HRM)
- Finance & Accounting (F&A)

HBE is responsible for all business education at the UT, which primarily takes place within the programs:

Bachelor

- International Business Administration (IBA)
- Business Information Technology (BIT)
- Industrial Engineering and Management (IEM)

Master

- Business Administration (BA)
- Industrial Engineering and Management (IEM)
- Business Information Technology (BIT)

Other figures from our 6 educational programs

	IBA bachelor	BA master	IEMs bachelor	IEM master	BIT bachelor	BIT master
Inflow (bsc 2019 and msc 2018)	201	170	157	89	99	27
Students population 2019/2020	489	363	416	233	196	94
Diplomas 2018/2019	93	163	76	75	22	31

Text: **Frederike Krommendijk**
Photos: **Eric Brinkhorst**

ROUND-TABLE DISCUSSION

Not everything that is technically feasible is also desirable

Will we soon all be wearing wristbands that our bosses can use to keep an eye on us? Will we still have permanent jobs, or will everyone be hired on a project basis? Will machines take over some of our work? These questions are all too real for the scientists at our round table. A discussion about technological possibilities and ethical and social consequences.

The annual job performance interview. Why even bother with that when you can use a wealth of data to analyse exactly who is and is not performing up to par? Anna Bos lists it as one of the issues that the field of human resources management (HRM) will face in the future. 'When you collect data on your employees, you can find out exactly what is and is not going well. You can also give much more specific feedback. Nevertheless, it will still take a manager to deliver that message properly and develop a long-term strategy,' she says.

According to Michel Ehrenhard, it is a manager's dream to measure, control and monitor everything. 'However, talking to someone about their job performance should not become a form of punishment. I do foresee a divide between higher-educated employees whose performances are harder to quantify with data and mass-production jobs where you can easily be replaced if you fail to reach your measurable targets.'

Leadership and creativity

Rainer Harms believes qualities such as leadership and creativity will become extremely important for managers and entrepreneurs in the future. 'You can leave routine tasks to machines, but the same does not apply to out-of-the-box thinking. Setting long-term goals will always be the responsibility of human employees,' he thinks.

All four believe it is important that students continue to think about the ethical and social consequences of the ongoing digitalisation, robotisation, machine learning, and artificial intelligence. Maarten Renkema: 'How do you set up your processes to retain that human touch? The goal should be to have technology improve the work done by humans.'

It is up to the university to engage in discussions with students during lectures to make them aware of the positive impact that technology can have, but also get them to think about the limits of its applications. 'Our students are all technology-minded, so that is not the issue. However, we must also instil in them a critical perspective and the awareness that they can set the limits of how they want to utilise technology in their own organisation or business,' Harms explains.

Widely accepted

In order to get society to widely accept a technological application, Renkema and Ehrenhard stress the importance of transparency. 'What data is being collected, who is behind it, what is it being used for? Without that openness, it will never work out. People will remain suspicious.'

Ehrenhard does not want fear to reign supreme. 'As a society, we can decide what to permit and what not. New developments such as artificial intelligence always have pros and cons. In addition to the potential dangers, they also present enormous opportunities. Our goal should be to enable society to benefit as much as possible from any new developments.'

Anna Bos mentions an example of a project in which chronically ill patients can perform their job with the help of technology such as video conferencing and home workspaces, even though they are not (yet) capable of returning to their old desk. 'Think of cancer patients for whom the trip to work is far too exhausting or chronically ill people who cannot work because they frequently need to rest or go to the hospital. Technology can be the bridge that allows them to participate in some manner.' In light of the ageing workforce, Harms also sees opportunities to keep older employees productive, for ▸

Maarten Renkema is researcher in Human Resource Management and a UT alumnus. Among other things, he is conducting research into innovative HRM, which stimulates employees to adopt new forms of working behaviour.

Anna Bos-Nehles is researcher in Human Resource Management and a UT alumnus. She obtained her PhD in Twente and her master's degree in Maastricht. In her work, she focuses on, among other things, the role of supervisors in the implementation of HR policy.

example because they have a quiet place to work at home. They both emphasise that it will be a challenge for supervisors to manage people in this manner. This is a skill they will have to learn.

Automating work

When simple tasks are automated, it leaves more time for other activities. Ehrenhard sees a challenge for policymakers. 'How can you make sure that the people who are pushed out of an organisation can still make a meaningful contribution to our society? Our society is increasingly focused on results and efficiency. However, countermovements are already popping up that focus on different values and ideals, and young people in particular are becoming more socially active,' he muses. According to Renkema, the fear that technology will eliminate all human contact in e.g. the healthcare sector is not necessarily justified. 'Much can and will be automated. This can save people time. Nurses will have more time to interact with their patients because they have to spend less time on technical or administrative activities.'

Might this development actually lead to even higher workloads? 'We have a government tasked with drawing up the right policies. We decide as a society just how these developments occur,' all four agree. It is up to employers to make it clear to their employees that any positive results will not be used to increase profits, but for the good of the whole organisation. Anna Bos: 'Otherwise, people will start to keep their good ideas to themselves.'

Fear makes for a bad advisor, the four say. In fact, Harms believes that businesses, organisations and governments should look for new opportunities in a more pro-active manner. 'Today's entrepreneurs must be fast, flexible and resourceful. The idea of a crazy inventor coming up with the next great invention in his attic does not work. You have to go out there and talk to people. If you have a good idea, the great thing about technology is that you can conquer the world with it in the blink of an eye. Just look at Gretha Thunberg: without digitisation she would still be an anonymous student, yet now she is rallying people from all over the world with her environmental message. You can make a product into a global success without ever setting foot on a plane. With new funding methods such as crowdfunding and digital platforms, you don't even need a bank or old boys' network anymore.'

'The great thing about technology is that you can conquer the world with it in the blink of an eye'

The four do not expect the formation of the new department to change much. 'Our departments have always interacted and collaborated extensively. We already sought each other out frequently. Nevertheless, it is good that new people are being hired as well who will be positioned at the interfaces between the former groups.' ●

Michel Ehrenhard is an associate professor and programme director of the (International) Business Administration programme. He studied Public Administration at the UT and focuses on, among other things, strategic entrepreneurship and leadership.

Rainer Harms is an associate professor of entrepreneurship. He obtained his master in economics and his PhD in political and social sciences in Münster. His field of expertise is strategy-making of technology-driven and international new ventures.

Text: **Frederike Krommendijk**
Photo: **Gijs Ouwerkerk**

PROFESSOR REZ KABIR POINTS OUT OPPORTUNITIES AND DANGERS

New technology has a significant impact on the world of business

Technology presents businesses with unprecedented opportunities. New funding methods such as crowdfunding, the rise of machine learning, big data analyses: the possibilities seem limitless. How can you utilise all these new developments responsibly? This is an area where the UT's IT, financial and business administration experts can support each other, says Rez Kabir, professor of corporate finance and risk management.

The world of business is changing as a result of new technology. Just five years ago, who would have thought that start-ups could finance their ideas through crowdfunding or that fintech (finance and technology) and virtual currencies such as the bitcoin would become so popular and that machine learning could make the commercial aspects exponentially more efficient? To take on these new opportunities and challenges, it is good that the new Hightech Business & Entrepreneurship department combines technological and business expertise, says Kabir. 'By combining our knowledge of management with technological expertise, we can find new solutions for organisational and social issues.'

'We combine knowledge of the soft management side with that of the technological aspects'

'Among other things, we study the success factors of crowdfunding. What information is important and is it more effective to introduce yourself with a video than with text alone? What convinces investors to part with their money to fund your business? With the help of technology, you can distil the success factors from the vast quantity of available data. This not only works for crowdfunding, but also for businesses that have gone public. The latter is a very costly process. When is the right time to make such a move? Alternatively, is it better to get other businesses interested in supporting you with a peer-to-peer loan?'

Ethical and security concerns

It is the researchers' responsibility to enable businesses to make the most of the new technological opportunities that are available to them, Kabir says. 'However, we must also shed light on the dangers that lurk in this new world, such as fake projects, cyberattacks and the bitcoin bubble. These technological developments not only affect businesses' commercial operations; there are also ethical and security concerns to be mindful of. From a marketing perspective, it is wonderful that you can gather a wealth of data on your customers through e-commerce, but where and how may this data be used? How do you prevent the theft or misuse of this data? In our education, we must prepare students for this new reality.'
What is the new department's main strength? 'It combines knowledge of the soft management side with that of the technological aspects. Before, we would all conduct research and teach students in our own fields. However, technology has become an inherent aspect of the modern world of management. At the UT, we cannot and do not want to be stuck on our own individual islands. Instead, we seek to combine our strengths for the good of our society.' ●

Text: **Jelle Posthuma**
Photos: **Archive**

Koos Krabbendam
Emeritus professor of Operations Management

FIFTY YEARS OF BUSINESS ADMINISTRATION

'We train engineers with business expertise'

Without business studies, there would be no Hightech Business & Entrepreneurship department. Business studies have been part of the UT's DNA for over fifty years. The time has come for a trip down memory lane, together with Koos Krabbendam, Olaf Fisscher and Petra de Weerd-Nederhof. 'Twente's business administrators are problem solvers who know how to get things done.'

More than half a century ago, a business studies programme was introduced at the 'Technische Hogeschool Twente (THT)', the Polytechnic University of Twente and the UT's predecessor. After Eindhoven, this was the second business studies programme in the Netherlands. Since the foundation of the THT in 1961, engineers educated in Twente have received a healthy dose of business expertise. This was part of the THT's basic philosophy, Koos Krabbendam knows. 'At the THT, we trained engineers with ample social knowledge, because there can be no technology without society.' Olaf Fisscher agrees with this philosophy: 'The social embedding of technology was a crucial aspect. Likewise, the moral reflection on technology has been a major factor since the very beginning.'

'Entrepreneurship is ingrained in our education as well'

Baccalaureate

During the early years of the THT, each engineering programme consisted of two parts. The first was a three-and-a-half-year programme during which students could earn their baccalaureate diploma. In addition to technical subjects, students were also educated in philosophy, social, and business studies. Next came a two-year study to earn one's engineering degree.
Olaf Fisscher and Koos Krabbendam were among the first Mechanical Engineering students to enrol in the business studies programme. After obtaining their baccalaureate, students could choose between continuing their engineering studies or delving into the world of business and management. This so-called top-up course in business, which also earned students a degree in engineering, was introduced in 1968. That marked the official start of the business study programme in Twente.

Putting technology into practice

Krabbendam: 'I thought this structure was ideal. If I had to set up a business studies programme today, I would do it exactly like that. Engineers got a technical education that included already some elements of business. Next, they took the top-up course, during which they could further specialise in business studies. This allows the engineers to put the technology into practice. That was the underlying philosophy. These days, such a principle is more relevant than ever.'
The baccalaureate was not a success, Krabbendam explains. Hardly any students embarked on a professional career with a baccalaureate diploma; almost all went on to earn their engineering degree. Furthermore, the two-phase structure was introduced in the Netherlands in the early 1980s. The so-called 'kandidaats' examination - i.e. the baccalaureate in Twente - was abolished, thereby reducing the total study duration to four years.
For Twente, this meant the introduction of Industrial Engineering and Management as a first-phase study, a four-year business studies programme with a so-called 'technical track' earning the candidates a proper engineering diploma. Petra de Weerd-Nederhof started this programme in 1985. She affirms the programme's technical nature. 'At least thirty per cent of the study involved hardcore technology, with subjects such as mechanical engineering, chemistry, and computer science.'

Petra de Weerd-Nederhof
Professor of Organisational Studies, specifically Organisation of Innovation

Olaf Fisscher
Emeritus professor of Organisational Studies and Business Ethics

Support

In the 1980s, the UT is designated as an 'entrepreneurial university' under the guidance of rector Harry van den Kroonenberg. This was huge support for the business studies programmes, Krabbendam knows. 'During those years, the University's administrators bestowed a lot of goodwill on the programme. Van den Kroonenberg worked like a catalyst for us.'

Entrepreneurship is still part of the department's DNA, De Weerd-Nederhof says. 'It's right there in the name: Hightech Business & Entrepreneurship (HBE). The 'E' has always been a crucial aspect of Twente's business education. Entrepreneurship is ingrained in our education as well. We provide education to students from other (technical) programmes, including mechanical engineering, computer science, and health sciences. It has been that way for many years.'

'We train doers'

In the 1990s, Krabbendam served as dean of the Technology and Management faculty. 'I saw the influx of new students drop. It was a dire situation.' Groningen and Rotterdam already offered general Business Administration programmes. We decided to introduce a similar programme in Twente. It attracted an entirely new group of students next to the technical management engineers. They had backgrounds in economics and social studies, for example. In doing so, we deviated from our original philosophy, which required our business students to possess ample technical expertise as well. We had no choice, though. It was an act of self-preservation. Without it, there would be no business education in Twente today.'

As programme director, Fisscher was there at the very beginning of the UT's Business Administration programme in the 1990s. 'Its profile is very clear. We train doers, problem solvers who know how to get things done. The people we train feel right at home on the work floor and are mostly interested in the primary processes.'

Top programme

The introduction of the Business Administration bachelor's programme was followed by two other important developments. In 2002 came the transition to the bachelor-master structure and in 2009-2010, De Weerd-Nederhof developed the English-language bachelor's programme, which was renamed International Business Administration (IBA) in 2013. Like Industrial Engineering & Management, the IBA programme has been selected as a top programme in the Higher Education Guide 2019. The Hightech Business & Entrepreneurship department was established in 2017. De Weerd-Nederhof: 'Looking back, this department is what the Technology and Management faculty used to be. Honestly, I am very happy about that. I see many businesses where our alumni work together closely, regardless of whether they studied Business Administration or Industrial Engineering & Management. Somehow, our alumni manage to find each other. Why? Because they were trained as business administrators in Twente.' ●

'Engineers educated in Twente have received a healthy dose of business expertise'

A SOLID ACADEMIC FOUNDATION:

Alumni reflect on the impact of their studies

Jeannine Peek (IEM'93)

Is now: Vice President & Regional General Manager at computer giant Dell Technologies

'It is important to choose and finish a study programme, because it gives you a solid foundation and a certain level of knowledge and skills. With that, your career is off to a great start. You should be open-minded about whatever happens next.'

From: Magazine for Alumni and Partners, winter 2019

Kees van der Graaf (alumnus Mechanical engineering and Industrial Engineering & Management 1974)

Former CEO of Unilever and former chairman of the supervisory board of the UT

Have you been asked for this position? 'That's right. I knew Erik van Amerongen, former lecturer at the UT, and he already thought I was the 'ideal candidate' for this position, given my management experiences and the fact that I am an alumnus. Indeed, the presidency of a supervisory board still lacked my range of activities. In that regard, this is a nice addition.'

From: UT Nieuws, 2011

Jitse Groen (BIT)

Is now: Founder & CEO Thuisbezorgd.nl / Takeaway.com

According to Groen, keeping a firm stance is the success of Thuisbezorgd.nl. `I just started and didn't really think about it. The number of orders has only increased and is still growing: sixty percent per year. We provide for the site with a need.'

From: UT Nieuws, 2009

Jitse Groen is the first billionaire of the HBE department and holds a position in the Quote 500 ranking.

Maarten van Beek (Industrial Engineering and Management)
Is now: director of Human Resources at ING

'I want to elevate the job to a higher level and work with evidence: measure how people's expertise develops when you invest in them. The foundation for that approach was partially built in Twente. I appreciated the fact that the programme offers a solid academic foundation and a focus on practical applicability. That combination is quite rare.'
From: Magazine for Alumni and Partners, winter 2017

Bregje Buiteveld (Industrial Engineering and Management)
Is now: Business Analyst at Coolblue

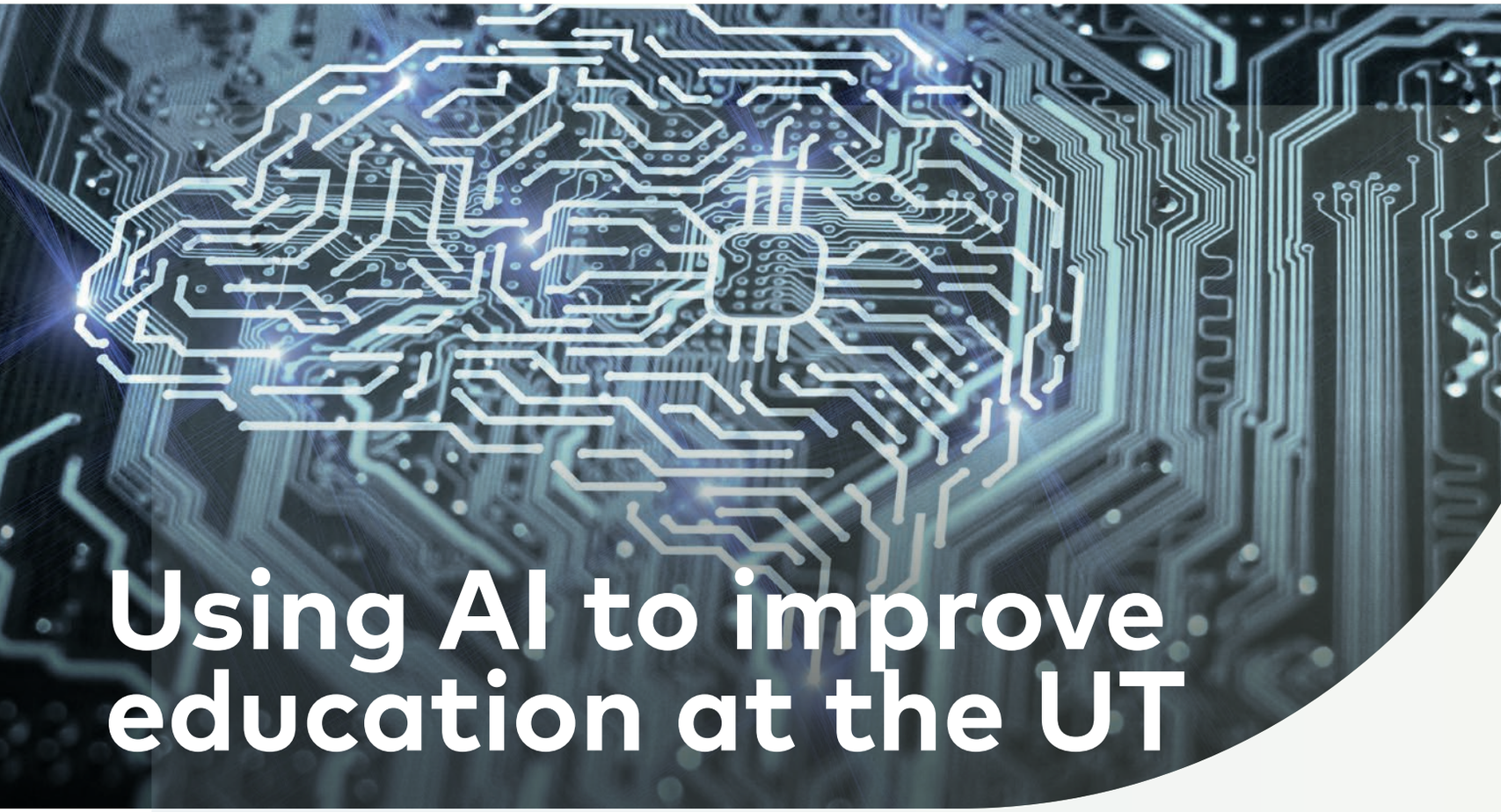
'My main takeaway from my studies in Twente is my technical background. I serve as a kind of translator between what the business wants and what IT can offer. I can bridge the gap between the two. Yes, my job is all about big data.'
From: Magazine for Alumni and Partners, winter 2017

Giels Brouwer (Industrial Engineering and Management)
Is now: Founder & CIO at SciSports & BallJames

Will SciSports follow in the tracks of Thuisbezorgd and Booking.com, two multi-million-euro companies that once started on the campus as student companies? 'That would be awesome. If BallJames takes off, things can move quickly. Very quickly. Every football club I talk to is interested. Where will the growth end? You should not focus on that. Expanding your business as quickly as possible should not be a goal in and of itself. What we want is for our products to make the game of football more enjoyable.'
From: UT News Career Special, March 2016

Some others on our wall of fame:

Lex Beins - Founder and owner Beins Travel Group Cheaptickets
Bert Bruggink – Former CFO Rabobank Group
Geert-Jan Bruisma – Founder Booking.com
Jan Dopper – Former member of the DSM Executive Board
Philip Sluiter – Owner and CEO O2 Capital
Marleen Veldhuis – International top swimmer, Olympic Champion and multiple world, European and Dutch champion.
Tom Eussen – Director Tata Steel
Robin Harleman – Director and owner Licentie2GO



Using AI to improve education at the UT

Sometimes, the work of Hightech Business & Entrepreneurship researchers strays beyond the boundaries of what you would expect from the department. Sometimes it could even prove to be more beneficial and even applicable for the university itself. That is the case with the work of Efthymios Constantinides, Rudy Oude Vrielink and Adina Aldea.

With artificial intelligence being one of the most disruptive technologies these days, researcher Efthymios Constantinides and four master's students looked at new ways to use AI as a marketing tool: using machine learning for segmenting potential UT students. 'From thousands of interactions of prospective students on the UT website, we identified search profiles of students most likely to convert – meaning actually starting a study here,' Constantinides explains. 'It starts with finding lots of reliable and anonymous data. Using this data and machine learning, we identified the potential students' search journeys and profiles based on the search behaviour of prospective students.'

'We were able to identify twelve different customer journey steps and six different visitor profiles. These findings could help the university marketing department to better assess the likelihood of someone becoming a student and better understand the UT website visitors' behaviour. Still, this is both a new tool and a first step. The next step for the marketers is to adapt their marketing strategy and efforts in line with the knowledge gained from this machine learning method.'

To Constantinides, the research offers a multitude of benefits. 'For students and marketing professionals, it is a new way to learn and solve a typical marketing problem, namely, to increase conversions. You can apply the

Text: **Rense Kuipers**
Photo: **Shutterstock**

same approach to for example underperforming studies and to any other type of business.'

Machines checking open answer exams

'I do have an enormous passion for integrating new technologies in education,' says Adina Aldea. That's why she's working on a way to automatically grade (digital) open question exams using machine learning, as a 'pet project'.

'Checking exams is a very tedious and repetitive task, especially when it comes to open question exams. And most of the time, answers are quite similar, but the length of answers can vary from a sentence to a paragraph or even a page,' says Aldea, posing the question: 'What if we could eliminate several problems, by automating the process?'

Without that many tools for open question exams, Aldea knew it came down to pioneering. 'I approached the subject in two ways. Firstly, by looking at standardising questions so it becomes easier to group answers that are more or less the same. Secondly, is the nuance in answers of open exams teachable to an algorithm? This is quite difficult, and I feel that we're making progress. In the ideal situation, when the algorithm groups the exams properly, you would only need to grade about five to ten exams, for groups of more than five times that size. It also helps students: if they are assessed in a similar manner, there is less bias in grading.'

For the future, Aldea thinks that an expert system might be a solution. That system could generate model answers, which could be compared to the answers of students. 'This is worth a try, for the benefit of both teachers and students.'

Never a classroom too full or too empty

Rudy Oude Vrielink did research on forecasting classroom utilization to improve timetabling. 'I know it sounds lame, but bear with me: it's the opposite of that. I believe I found a way to reduce costs by using classrooms more efficiently, while at the same time giving true power to teachers.'

He already took an important first step, by using sensors that he placed in 55 lecture rooms all over campus. With at least 90 percent accuracy, these sensors monitor how many students are in a lecture hall, real-time. An example: Waaier 3, with a capacity of 135 seats, had only 38 seats occupied at the time of the interview. 'Teachers tend to overclaim lecture rooms. They expect all students who follow a course to show up – sometimes even more than that. That's almost never the reality.'

By keeping track of the occupation and utilization of lecture rooms and rebooking rooms last-minute when needed, Oude Vrielink thinks the university can save at least 300 thousand euros a year. 'That's the first step, that can already be implemented – if the university wants,' he says. 'The second step is to schedule courses based on appropriateness and enhance a community feeling by having classes of the same study near each other. The third step is to use data to predict the influx of students. The fourth step is to combine all previous steps and have true adaptive scheduling.'

'Imagine a university where a system learns from the feedback of teachers and the data from the room sensors. Imagine that teachers and students automatically receive a message each morning where their classes are. Imagine that we don't have to use an entire education building, because everyone fits. Imagine happy teachers that know they get the room they prefer, to give the best education possible. That situation might feel far away, but it is very much in reach.' ●

Adina Aldea

Efthymios Constantinides

Rudy Oude Vrielink

Text: **Frederike Krommendijk** Photos: **Archive and Frans Nikkels**

THE POWER OF COLLABORATION

'An enrichment of my professional knowledge'

Benefiting from each other's expertise. For these four scientists, that is the biggest opportunity that the new department offers, for example in the field of Smart Industry. 'No matter what wonderful technological solutions we come up with, there is little point to our work if they are not accepted.'

Tanya Bondarouk, Professor of Human Resource Management, founder of the research theme of electronic HRM

'Simply put, we study the possibilities that technology creates in the field of personnel management. That covers everything from recruitment and selection to assessments and applications, as well as performance interviews. What can be handled digitally and what should we keep doing face to face? We are hard at work on our research, and I am proud of the fact that we were able to organise the first international conference in this field back in 2006. Since then, a large international community has started working on this theme and biennial conferences are held. We started with a simple question: is electronic HRM truly useful in an organisation or is it little more than a fad? We looked at various businesses and organisations, ranging from hospitals and ministries to major companies like Shell. Digitalisation is part of modern HRM; the days of publishing wanted ads in the daily papers are gone. However, it cannot replace the strategy of HRM. It is important to first set up your HRM processes properly, before you start to focus on digitalisation. Technology is a means, not an end.

It is important that digitalisation is presented as an opportunity. Some tasks will require fewer HRM officers, while areas such as artificial intelligence and data analysis will require more.

The new department gives us a new perspective on our field. When it comes to the self-scheduling of police officers, for example, our mathematicians look at the technical requirements, while we focus on the personnel. I think it is wonderful that all this expertise is now being brought together.'

Holger Schiele, Professor of Technology Management and Supply, with a focus on smart supply.

'We will have to improve our productivity. That is not something we as researchers came up with; it is a simple result of the shrinking working population. The number of people retiring exceeds the number of new employees entering the workforce. Autonomous systems are necessary. Whenever I teach workshops for businesses, I immediately substantiate that necessity with hard data. If I don't, someone will invariably ask me if all this is really necessary.

One of the things we are working on is an avatar that negotiates on your behalf during the purchasing process. The software takes

Maria Eugenia Iacob, Professor of Business Information Systems

'My areas of expertise are enterprise architecture, designing business information systems, and artificial intelligence. Together with my PhD students, I work on a framework for intelligence amplification. The basic principle is to have intelligent systems take over some of the work that is currently being done by humans, while still having people in the lead when it comes to complex decision-making processes. For many operational processes, more than eighty per cent of the decisions are routine. Artificial intelligence can take over the majority of these decisions. The advantages are that there is no risk of error, enormous quantities of data can be processed in a short period of time, and the system never gets tired.

A few years ago, we looked at the logistical planning of shipping containers with the help of a serious game. It is a very complicated system: every client has its own demands with regard to e.g. costs and service levels. Artificial intelligence can be used to efficiently draw up this planning, so the planners can focus on resolving complex issues such as a transport that is delayed due to a malfunction. In other words, it is about dividing tasks between human employees and computers. We found that doing so results in better decisions than having either people or computers go it alone.

For humans, it can be difficult to let go and trust the system to do a good job. It requires a behavioural change and a new way of working. That is why it is great that we can work together with others in this department who know all about the behaviour of people and organisations, entrepreneurship and change management. No matter what wonderful technological solutions we come up with, there is little point to our work if they are not accepted. For me, the new department represents an enrichment of my professional knowledge.'

Desirée van Dun, Assistant Professor Change Management & Organizational Behaviour

'On a global level, we specialise in the high-tech video observation method for field research within organisations. At ING, for example, we have teams wearing wristbands to track physiological data in everyday work situations. This allows us to carefully map the behavioural patterns of supervisors and team members, including their physical effects. Much of the research in our domain is conducted with the help of surveys, interviews and observations with the naked eye. We offer a new, more objective perspective. This form of high-tech pioneering with a human touch is very interesting to me.

Concretely, we are working with international organisations and universities to conduct research into change processes at the organisational, team and individual levels. Change impacts the dynamics between supervisors and employees and between employees themselves. We try to find out exactly how people's behaviour and values are affected. We conduct our research in the private and public sectors, for example in healthcare, production, coaching, and consultancy organisations. We also look at cross-cultural change programmes that focus on agile, lean, and continuous improvement.

Lastly, we supervise many external PhD students with extensive professional experience, just like I used to be. They come to us with socially relevant research questions. This means our findings are often immediately put into practice. At the Ministry of Defence, we are conducting action research with a postdoc. Using our interim research results, we help employees and supervisors reflect on where they currently stand and what they can improve. This kind of meaningful research inspires me.

For example, we have learned that emotionally intelligent supervisors and collectively setting targets can boost a team's spirit, usefulness and results. The department can contribute to more collaboration with colleagues from other international publishing groups, so we can realise an even better research programme together.'

over the negotiations and can compare every imaginable parameter, such as prices and service levels. It will then find the best possible deal. When you realise that seventy per cent of the revenue of the average Dutch industrial organisation is spent on suppliers, it becomes clear that there is a lot to be gained here. Businesses have already shown great interest in this system.

In typical UT fashion, we are not merely approaching this research from a business or technical perspective, but we are also considering its social impact. Although people are often afraid of technology taking away their jobs, we need it to safeguard our future productivity. If we do not let people experience the social benefits of technology, it becomes much harder to garner support from an organisation's workforce. That characterises Twente's 'high tech, human touch' approach. Collaboration between different departments is part of our DNA. In this department, we benefit from each other's specific expertise and look for solutions together.'

Text: **Michaela Nesvarova** Photos: **Shutterstock**

ARTIFICIAL INTELLIGENC IN LOGISTICS

The future is self-organizing

'Logistics is a lot more than just transport,' say researchers Martijn Mes and Sebastian Piest. And their field of expertise, the use of artificial intelligence (AI) in logistics, has the potential to change a lot more than you might think.

Martijn Mes
(associate professor)

Sebastian Piest
(PDEng)

Thanks to the use of AI in logistics, sending physical goods can soon become the same as sending an email. 'By using sensors and software in shipping entities, such as containers or pallets, we could move towards a self-organizing logistics system,' explains Mes. A container would simply be given an objective to arrive at a certain destination before a certain deadline as efficiently as possible, and it would 'send itself' there, using its sensors and ability to communicate with its environment. 'We'd just say "good luck, container, now find your way". That is exactly what you are doing in a digital form when sending an email. This translates the idea of the digital internet into a cyber-physical system: the physical internet.'

Sci-fi or reality?

Looking into such ideas and making them a reality is precisely what these researchers do. 'We are studying possible applications of AI in logistics,' says Piest. 'We are exploring where AI is already used and where it could be used in the future. Essentially, we are determining what is available, what is feasible, what needs further development, what is required from a policy or legal perspective and what is sci-fi.'

While 'self-sending' containers might not be commonplace for years to come, AI has already found its way into the field of logistics. 'To what extent largely depends on your definition of AI,' warns Mes. 'In essence, AI can be defined as an intelligent virtual or robotic system that mimics human cognitive functions, such as communicating, remembering, perceiving, learning, problem solving and so on. With respect to problem solving, we are beginning to use data driven systems to make logistical planning more adaptive and efficient.'

What most people imagine as AI, meaning intelligent machines and software operating on their own, is currently mostly used in warehouses, clarifies Piest. 'We already see a lot of autonomous guided vehicles moving cargo and drones doing inventory in warehouse facilities, for instance. The next step is to apply AI in supporting front- and back-office processes. Together with industry partners, we are designing and implementing intelligent agents and conversational chatbots to automize routine tasks, such as processing shipments and customs documents.'

Intelligence amplification

Many planning and scheduling tasks are traditionally performed by human workers. 'Yes, AI will have a big impact on job demands and the labor market, which is also something we are studying,' adds Piest. 'We are analyzing the possible societal impacts of AI regarding the future of work, learning and education. In our view, AI is not about replacing humans. We rather talk of intelligence amplification and look at how we could enhance performance. We try to identify which tasks are boring or too monotonous for humans and see if a machine could do them instead. That way people would have more time for other, more complicated and interesting tasks.'

However, there is one skill in which machines clearly outperform humans and could take over from us: pattern recognition in large datasets. AI has access to real-time data, such as weather, traffic, track-and-trace and other sensor information. It could handle this abundance of information and make sense of it, explains Mes. 'It could find patterns humans wouldn't, and so it can significantly improve all kind of decision problems, such as planning, scheduling, routing, workflows, etc.'

Lifesaving AI

AI in logistics could also save lives. In the past, Mes worked with various police departments to use AI for prediction of crime. The police used the smart technology to predict where crime is most likely to occur, and determine the routes of their surveillance vehicles. The system was also used for police helicopters that are now flying based on these predictions, as the helicopters can only make a real difference when they are on the scene within fifteen minutes.

Now, Mes and his group are starting a new potentially lifesaving project, this time focused on humanitarian aid. 'Logistics are currently the main costs of humanitarian aid missions. We aim to reduce the logistics costs and improve the response time using drones. After a natural or man-made disaster, we can use swarms of drones that autonomously decide where to go, determine where help is actually needed, provide deliveries of medicine, water, blankets and so on, but also gather information on the affected area and establish a communication infrastructure. See, logistics is a lot more than just transport.' ●

How does 'AI in Logistics' research fit into the Hightech Business & Entrepreneurship department?

Mes: 'What unites us within the HBE department is our joint interest in business analytics. Although our focus is on logistics, the data-driven techniques we use are very well applicable to other industries and other business functions represented by our colleagues in HBE.'

Piest: 'AI is an interdisciplinary field with numerous application areas and societal implications. Based on the research and expertise of our cluster, we together can facilitate AI adoption in logistics and design responsible, trustworthy and explainable AI solutions.'

Text: **Rik Visschedijk**
Photos: **Shutterstock**

MAKING HEALTHCARE MORE EFFICIENT, CHEAPER AND MORE EFFECTIVE

'We can objectify choices'

The healthcare sector faces enormous challenges, such as the ageing population, more demanding patients, personalised care and the affordability of the latter. Erwin Hans, Professor of Operations Management in Healthcare, travels all over the world to explain that the logistics in the healthcare sector can be improved and made more efficient.

Professor Erwin Hans still has an engineer's perspective on healthcare. Roughly fifteen years ago, he made the switch to the healthcare sector, although he has a background in mathematics and technical business administration. 'A friend introduced me to an operating room manager, who invited me to apply my knowledge of logistics to the healthcare sector. I was shocked at how inefficient the planning was.'

The surgery schedule often ran in overtime, because surgeries took an average of forty minutes longer than planned. Hans learned that the estimate of the duration of a surgery was based on the time that the surgeon was present. 'They did not account for the preparation before and the clean-up after the surgery. I was baffled to learn that they did not use the historical duration of a surgery, which is after all the first step of logistical improvement.'
When it comes to planning and logistics, the sector is running far behind the industrial sector, says Hans. 'We want to make healthcare more efficient and therefore cheaper, but also more effective: patients receive better care and staff get more pleasant working conditions.'

Changes have to be made to healthcare logistics, says Hans. 'The number of options available to patients is growing, the quality of healthcare is improving and care is becoming increasingly personalised. However, that involves far-reaching specialisation. We see an increase in the number of service windows where patients have to go. Capacity, such as manpower and equipment, is being dedicated to specific care.'

More service windows, each with its own queue, means longer waiting times. As more and more people need care, these waiting times grow rapidly. A single service window for all treatments is a utopian ideal, of course. However, it is also impossible to offer every patient fully personalised care, Hans states. A balance must be found. 'With our knowledge of mathematics and operations management, we can objectify choices. This lets you make responsible decisions, both for patients and for society as a whole.'

Islands

Another sore point is the islands policy that plagues the healthcare sector. Hospitals turned their departments into so-called result-responsible units (single cost centres). 'These islands seek to optimise themselves by making full use of their capacity,' Hans says. 'However, when you look at the hospital as a whole, this approach is often inefficient. The agendas of the various departments are poorly coordinated. The hospital does not sufficiently account for fluctuations of supply and demand in the entire chain.'
That problem will only grow in the years to come as healthcare becomes increasingly personalised. 'You will end up with more specialists and therefore more service windows,' Hans continues. 'There is an entire operation

Erwin Hans

Professor of Operations Management in Healthcare

behind each service window. Let's say a restaurant allows you to order a fully custom-made meal. Curly, thin, straight or long fries, peanut oil or sunflower oil, etcetera. Each ingredient needs its own specialist. That would make the food unaffordable.'

Taking steps

There is no one-size-fits-all solution for this problem, Hans says. 'However, you can certainly take steps. Use data to make predictions: when are your peak times and when do you need less capacity? Take an integral look at your capacity, instead of dividing your hospital into myriad islands, each with its own rigid schedule. Start mapping out ways to fund the care you provide.'
These logistical changes designed to keep healthcare affordable cannot come from a single source, Hans states. 'It will require input from mathematicians, industrial engineers, and financial experts. The social sciences must also be involved: it is partly about behavioural changes and accepting new technologies and working methods. It is clear that something must be done.' ●

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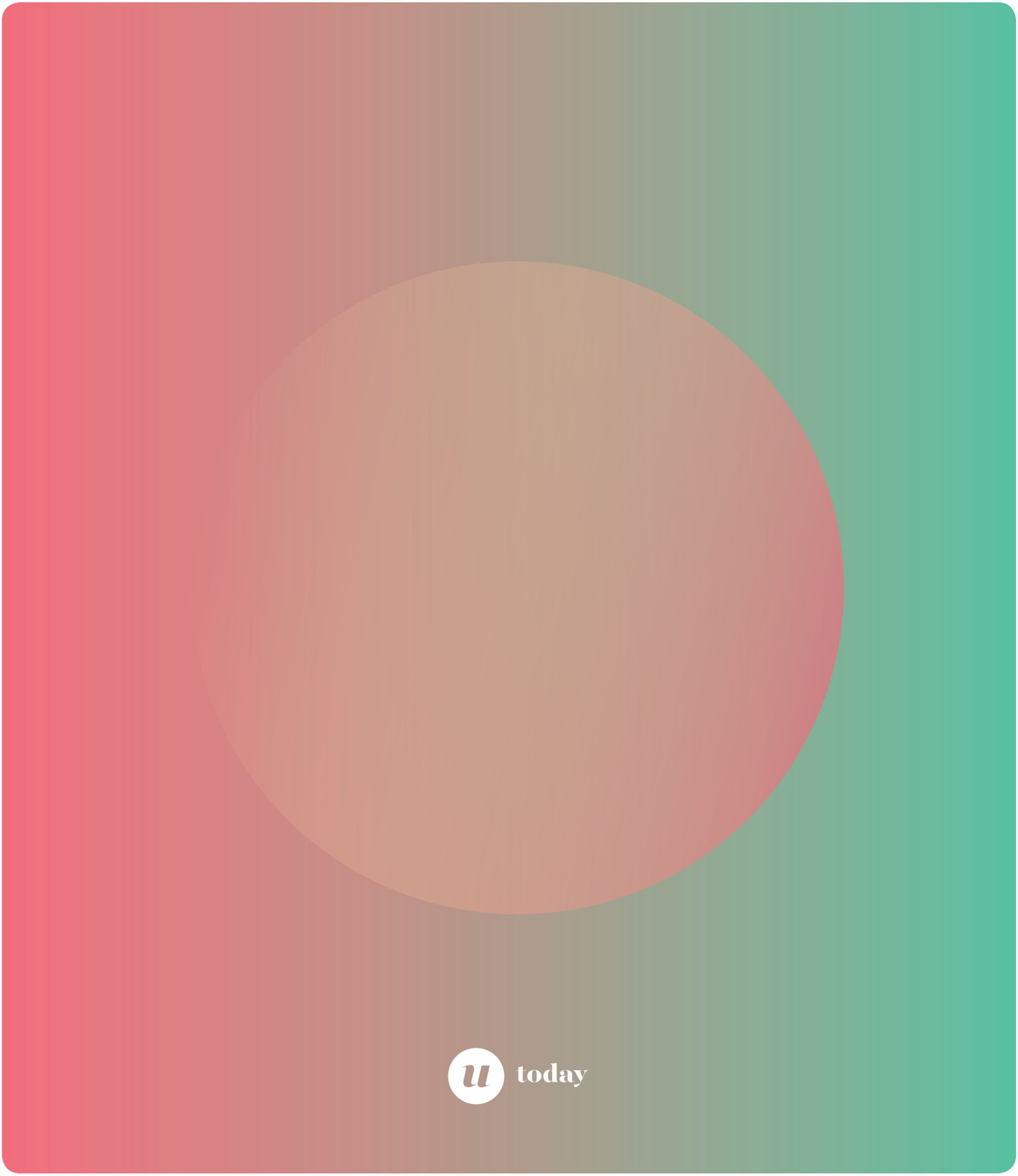
The Hightech Business and Entrepreneurship (HBE) department studies and designs solutions for sustainable renewal of industry by value creation with technology. In doing so, HBE specifically strives to support organizations in innovative and entrepreneurial management and decision making. With that, HBE embodies the Hightech Business Institute of the UT.
HBE focusses on digitalisation within the domains smart industry and healthcare, ranging from smart decision support systems and IT implementation in various business functions to strategizing and business development in business ecosystems by start-ups and incumbents.



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