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TECHNOLOGY
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Technology and people

A life without artificial intelligence (AI) is no longer conceivable in 2020. Not for a city like Amsterdam, but not for me either. As you may know, Amsterdam has been using numerous AI applications for many years. If the waste container in your neighbourhood is full, a member of the municipal cleaning staff will be notified. And when it's busy on the Kalverstraat or at the Johan Cruyff Arena, *crowd control* takes place with the help of cameras and computers. But as you can read in the interview with UvA president Geert ten Dam (from p. 4), the developments in this field are taking place in record time and the Netherlands is in danger of missing the boat. We cannot allow that to happen and that is why I am extremely happy and proud that nine Amsterdam institutions have joined forces under the banner of AI technology for people. Within this coalition, the very best scientists are jointly working on solutions to come up with solutions to metropolitan problems. This coalition can best be seen as an ecosystem in which knowledge and skills are shared without losing sight of issues such as unwanted data sharing and privacy.

There are countless applications of AI within the domains of Health, Citizens, and Business, and that is why I read this special edition of popular science magazine *New Scientist* with great interest. The editors interviewed researchers, visited labs, spoke with promising talents, and identified the number of companies active in this field. And the extraordinary thing is that almost everything comes together in this magazine: education, research, business, people, government, and politics. This is also important, because sooner or later every Amsterdammer will have to deal with AI.

Femke Halsema
Mayor of Amsterdam

A PUBLICATION OF
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AI TECHNOLOGY FOR PEOPLE

COVER DESIGN:
PASCAL TIEMAN

'Joining forces and being people-oriented are important'

When it comes to artificial intelligence (AI), the Netherlands is lagging behind the rest of the world. That is why nine Amsterdam institutions have joined forces in the AI technology for people coalition. A conversation with initiator **Geert ten Dam** and ambassador **Anita Nijboer** about smart search engines and useful networks that converge in Amsterdam's multicultural ecosystem.

Text: Marleen Hoebe and Jim Jansen
Photography: Bob Bronshoff

The Roeterseiland campus is almost deserted as we go into our appointment with Geert ten Dam and Anita Nijboer in mid-July. There are hardly any students to be seen and there are only a few lost tourists in the pavement cafés of CREA Café and Filmtheater Kriterion. From her office on the sixth floor, Ten Dam, in everyday life president of the University of Amsterdam and, in that capacity, initiator of the AI technology for people coalition, can oversee the entire area. Again, AI applications are never far off. A robot camera monitors safety and the soap dispenser in the toilet starts automatically when you hold your hand under it. The appointment was made to discuss the AI technology for people coalition, a link between participating institutions and the way in which knowledge and skills are shared.

'By initiating projects together, we develop the knowledge and applications of AI faster and better,' Ten Dam says, not without pride. Anita Nijboer adds, 'It's about an integrated approach throughout the entire chain, and the focus is always on people. Questions about social acceptance are addressed by the Amsterdam University of Applied Sciences (AUAS), for example; they are looking at applications of AI in the public space or in SMEs. The University of Amsterdam (UvA) has a great deal of expertise concerning *machine learning*, or *deep learning* [developing technology that computers can use to learn from data, ed]. The Vrije Universiteit Amsterdam (VU Amsterdam) has knowledge of *knowledge-based learning* [developing technology to allow computers to learn from human knowledge, ed.]. The CWI National Research Institute for Mathematics and Computer Science also does similar *high-end* research. The hospitals and Sanquin blood banks have a great deal of data on health at their disposal and they are taking the lead in medical diagnostics and prevention. The municipality focuses on the policy side of AI and its applications for citizens.'

This coalition is new, but Amsterdam's knowledge institutions have been working on AI for some time now.
GtD: 'Certainly. Two years ago, we appointed four university professors in the field of AI at the UvA. They cover the different facets of AI, from information processes and search engines to the legal implications of automated decision-making. But we aren't doing it alone. The VU Amsterdam is the leader of a major Gravitation programme aimed at improving the collaboration between man and machine. The AUAS has a professorship

CV

- **Geert ten Dam** (1958) was the chair of the Council of the Education Council of the Netherlands. Since 2016, she has been the chair of the University of Amsterdam and initiator of AI technology for people. She is also a Crown-appointed member of the Social and Economic Council of the Netherlands.

in Responsible IT. All this knowledge is needed for AI to be of real value to society and to make full use of its innovative power.'

When the term AI is mentioned, it is usually followed by words such as 'privacy' and 'laws and regulations'.
AN: 'AI is always about sharing data. And we are already sharing a lot of data without knowing it. For example, your phone is full of AI, and every time you use it, bytes cross the ocean to *big tech*. Do you agree with that in terms of privacy? What happens to that data? Of course, it's not only about data on a phone, but also about patient data, for example. It is essential for hospitals to be able to exchange data with each other in a

responsible way in order to learn from it. This not only benefits patients, but also healthy people. In other words, medical science will only advance if you can learn from previous cases.'

What makes the collaboration between the knowledge institutes so strong?
GtD: 'Developments within AI are rapid, and our strength is the integrated approach. We can only keep up with these developments and guide them together. We need each other and that penny dropped in Amsterdam.'
AN: 'The collaboration allows the institutions to join forces and create more knowledge and expertise. In addition, AI encom-

passes so many aspects that can now be included. Just take a look at the projects and initiatives that are highlighted below. Joining forces is so incredibly important, because, if we don't invest in AI, the Netherlands will fall behind, also compared to other European countries. It is even questionable whether we can still catch up in some areas. Investments should, therefore, not only be made in AI in Amsterdam, but in all major

Amsterdam collaboration

AI technology for people is a collaboration between the Amsterdam Economic Board, the Amsterdam University Medical Centre, Antoni van Leeuwenhoek/Netherlands Cancer Institute, the National Research Institute for Mathematics & Computer Science, the City of Amsterdam, Amsterdam University of Applied Sciences, Sanquin, the University of Amsterdam, and Vrije Universiteit Amsterdam.

'We need each other, and that penny dropped in Amsterdam'

The ambitions of AI technology for people

CV

Anita Nijboer (1962) studied law at VU University and tax law at the University of Amsterdam. She was a partner at PwC and is now a supervisor. Since 2019, she has been an ambassador for AI technology for people.

Investment ambition for the next ten years

- Investment of 1 billion euros
- At least 800 researchers
- To train at least 5000 bachelor, master, and PhD students
- To have 10,000 students take an AI minor
- To help develop at least 100 spin-offs and 100 start-ups

With a focus on three domains

- Business Innovation
- Citizens
- Health

The starting point is an integrated people-oriented approach throughout the entire chain in the Amsterdam metropolitan region: 'Amsterdam as a living lab'

And working with three interwoven core technologies

- Machine learning
- Responsible AI
- Hybrid intelligence

The recommendation committee consists of:

Femke Halsema mayor of Amsterdam
Corinne Vigreux co-founder of TomTom, founder of Codam
Chris Buijink chairman of the Dutch Banking Association
Sigrid Johanisse Innovation, Technology & Science advisor, Foreign Affairs/ embassy in Washington
Marietje Schaake Stanford University, president of The CyberPeace Institute
Alexander Rinnooy Kan emeritus professor of Economics and Business Administration
Peter van Sabben CEO & co-founder of GrowthTribe
Pieter Senster engineering director at Databricks
Jeroen Tas Chief Innovation & Strategy Officer Philips

ecosystems in the Netherlands, for example in the Delft, Rotterdam, Leiden, Eindhoven, and Wageningen clusters.'

Why is the Netherlands lagging behind?
GtD: 'The Netherlands has invested far too little in AI. A PhD student trained here is often bought up by another country. In Germany, AI professors receive a substantial budget and a number of PhD candidates upon appointment. In the Netherlands, the most important thing we need is an encouraging innovation climate and collaboration between knowledge institutions and companies. This leads to flourishing talent, and talent in turn attracts talent. This requires investments.'
AN: 'Research shows that talents are being lured away from the Netherlands: to Silicon Valley or China, but also to places closer to home, such as Berlin. Germany is one of the European countries that invests a lot of money in the further development of AI. The Netherlands should take that as an example.'

What should Amsterdam do to retain talent?
AN: 'Amsterdam should create an ecosystem in which talents can thrive and develop further, because they are able to work on new business propositions at innovative companies such as Adyen and Philips, but also at start-ups. You want to keep companies like these in the Netherlands.

Fortunately, Amsterdam is still seen as a nice place to live and study.'
GtD: 'In addition, contact with other highly innovative ecosystems in the Netherlands is crucial. It's not just about Amsterdam. We have to enhance each other in order to enhance the Netherlands and, in doing so, make the Netherlands a strong European player in the field of AI. We really need to scale up.'
AN: 'Amsterdam can't do it alone, but we

can work on all kinds of projects here. These projects can then be rolled out more broadly. Amsterdam is an orderly city, with a great diversity of people and a lot of creative talent. Amsterdam is a *living lab*.'

What projects are currently underway?
AN: 'All projects fall within three domains: *business*, *citizens* and *health*. In business, for example, we have labs at major companies at the Amsterdam Science Park, including

'The Netherlands will fall behind if we don't invest in AI'

Ahold Delhaize, TomTom, and Elsevier. At these labs, there are five PhD students working under the supervision of a professor and someone from the company for five years. The municipality also plays a role in the citizens' domain. Take, for example, *crowd control*, the placement of EV charging stations, but also research into the application of AI in the field of education, welfare, the environment, and mobility.'

GtD: 'There used to be law centres, where there were people who could help you to write a notice of objection. Now people can simply upload their data online to UvA's Amsterdam Law Hub and receive a notice of objection tailored to their situation. Data science and AI make that possible.'

What is happening specifically in the field of health?

AN: 'On the one hand, improving care, and on the other hand, prevention. We recently appointed a professor who will focus on AI

and health. A very recent example for the treatment of disease is the sharing of ICU data of patients treated for COVID-19 (within legislation and regulations, of course). A project in which the Amsterdam UMC was already involved but in which many Dutch hospitals are now participating.'

GtD: We are also working with the Amsterdam Economic Board on a data-sharing system, a platform with which data can be exchanged in a responsible manner. The intention is that data can be shared in such a way that the data remains the property of the person who collected the data. This way, no monopoly behaviour will occur.'

How do you see the future?

AN: 'AI is not something you study from behind your desk for a few years and then roll it out. I like to quote AI professor Maarten de Rijke: 'You have to get on the highway, don't wait, but make sure there is a crash barrier along the road. It doesn't matter if you hit that crash barrier once in a while without causing major damage.' The essence of AI is that you learn from application, from data, but with the focus on people.'

GtD: Amsterdam's knowledge institutes have built up a wealth of knowledge about data science over the past twenty years. We are sharing this knowledge and that benefits everyone.' ∎

column

Sustainable added value

AI is rapidly penetrating all the capillaries of society. Applications are popping up everywhere with major consequences for almost all sectors and occupations. This raises all manner of questions for the government, companies, and in the public debate. Questions regarding education and talent, but also questions of a social, societal, and ethical nature, such as: when and how do we want to shape AI in society? How can we design solutions that offer added value for all parties involved? What values do we use to guide our designers, developers, and researchers on their way?

This is an opportunity and a task for (higher) vocational education and practice-based research. The Amsterdam University of Applied Sciences (AUAS), together with its partners, is taking up the gauntlet and will soon offer AI literacy to all its students and staff. Our practice-based research will interpret the social implications of AI and develop knowledge and methods to integrate AI in society in a meaningful way. In doing so, we prepare current and future professionals for a world in which AI plays an important role – and everyone needs a perspective for action in order to make responsible choices.

That is why AUAS has chosen to significantly strengthen AI education and research. This year, we started the AUAS-wide Centre of Expertise Applied Artificial Intelligence that bridges the gap between education, research, and practice. It bundles knowledge from seven thematic labs and makes them available to all our programmes, lectorates, companies, and governments. Think, for example, of applications for legal practice, accounting, controlling and finance, retail and marketing, maintenance of machinery, buildings, and mobility, education, the creative industry, and welfare and health.

We are convinced that AI can only have sustainable added value if we focus on responsible, inclusive, explainable, and workable systems that we develop in and for actual practice. We are happy to contribute to this with conviction. If you would like to participate, please feel free to contact us.

Frank Kresin is Dean of the FDMCI & secretary of CoE AAI io.

CV

Frank van Harmelen

29-10-1960, Bussum

- **1978-1983** mathematics and computer science studies, University of Amsterdam
- **1985-1989** PhD research into meta-level reasoning, University of Edinburgh
- **1990-1995** postgraduate AI researcher, University of Amsterdam
- **1995-2001** AI researcher with focus on semantic web and knowledge representation, VU University Amsterdam
- **2001-present** professor of Knowledge Representation and Reasoning, VU University Amsterdam
- **2019-present** principal scientist Hybrid Intelligence: augmenting human intellect, alliance of six Dutch universities, winner Gravitation subsidy

'We want AI to be a fully-fledged colleague'

Frank van Harmelen is one of the initiators of the largest AI research project in Dutch science history: Hybrid Intelligence. His mission: to develop computers that can make plans and solve problems.

Text: Tamara van 't Woud
Photography: Bob Bronshoff

You are Professor of Knowledge Representation and Reasoning. What makes reasoning difficult for a computer?
'Reasoning requires knowledge. How do we represent knowledge in such a way that a computer can reason with it? Things that are very easy for people are very difficult for a computer – and vice versa. In AI, we call this Moravec's paradox, named after a researcher who observed this back in the 1980s.

A standard example of this is having a conversation in a natural way: hearing what you say, understanding the language, understanding the context so well that you give it the correct meaning, and then giving an answer that is tailored to the listener. I talk to you differently than I talk to my colleagues. I know pretty much what you know, and I tune my answers to that. The conversation has a purpose. And I know that you know that I know what the purpose is. A toddler of four can assess that as well. But for a computer, that's very difficult.'

That sounds very practical, that people are good at what computers are bad at and vice versa. Why are we afraid that computers will replace people?
'The basic idea underlying the Hybrid Intelligence project is precisely that people and computers can complement each other. We want to work towards a hybrid team of people and computers working together. We think such a team is better at some tasks than a team of just people or just computers.

Within the HI project, everyone contributes on a different level. In Delft, for example, they are good at the social side of computers, so they work on the collaborative aspect. A colleague from the VU is working on langua-

ge technology, which is about the communication between computers and humans. In Groningen, there is a team member who works together with cognitive scientists. And a UvA colleague is working on self-learning computers. Each participating university has its own role. The two universities in Amsterdam are leading the project, and the other four are contributing expertise that we don't have.'

What do you expect from the future of AI?
'I think we're dropping the science fiction film-like idea of computers being intelligent in the same way that people are, and we are focusing more and more on human-computer collaboration. To do that, we have to study other AI questions than we've done up to now.'

Such as?
'Computers are a little autistic now. People are constantly thinking about each other's knowledge, objectives, and motivations. This enables us to work well together in teams. Computers have to get better at this. So far, this is an underexposed aspect of AI, which is why it is so good that six Dutch universities are going to work on this in a collaborative venture.'

You sketch an optimistic scenario, but the world consists of more than well-meaning scientists. What is the pessimistic scenario?
'Uneven distribution of the benefits of technological revolutions in society. We saw the same thing happen with the Industrial Revolution: initially factory owners became very rich, and the workers became very poor. It took a hundred years before the benefits were distributed a little more evenly. There are concerns that this will be the case with AI.'

How do the results of the Gravitation Project reach society?
'Our particular focus is on application in education and healthcare. For example, a colleague is experimenting with robots in children's hospitals. They can provide information if a child asks when mom and dad will be visiting, or why they need to be in hospital. A robot like that would be part of the hospital staff.

The challenge for us is to become the first team to publish a scientific article of which AI – which we have already christened AI-nstein – is a co-author. That means AI must have contributed to every step of the process, from the formulation of the hypothesis to the final publication. We want AI to join the team as a fully-fledged colleague.'

Including lunch breaks?
'That could be the hardest thing of all.' ■

Fundamental centre of development

V U University and its (Amsterdam) partners are making dizzying progress in various fields of science using artificial intelligence (AI) and data science. What I find striking about our research, to which more than twenty VU professors and their research groups are contributing, are three things.

First of all, on the basis of a fundamental structure, our research is making astonishing contributions to many applications. In the field of health and care, for example, we are developing care robots, AI for the prevention of suicide, and the development of AI-driven therapies to support people with depression. With regard to (business) organisations, our research ranges from the development of an instrument for the police that predicts misconduct and crime to an AI instrument to manage successful recruitment and selection at companies.

A second notable feature of our research is that it often focuses on hybrid intelligence, that is how artificial and human intelligence complement each other. The aim is optimal collaboration between people and machines instead of replacing people by machines. Intended applications here are the use of robots as teaching assistants in the classroom, robots as buddies for children in hospitals, and AI as a collaborative partner of scientists.

Finally, it strikes me that we are working together so much in this field of science. Not only with other knowledge partners, in Amsterdam and internationally, but also with other organisations on a large scale. And research teams are not only made up of hard scientists, but also scientists from other disciplines, such as linguists, business experts, doctors, psychologists, criminologists, and human movement scientists.

All in all, I am enormously proud of the rapid growth of our research and education in this field. Although this sometimes makes a new building too small at its opening, our contribution to social challenges based on often multidisciplinary and translational research is spectacular. It is, therefore, logical that we see artificial intelligence and data as a fundamental centre of development of the VU University Amsterdam.

Mirjam van Praag
President of the Vrije Universiteit Amsterdam

City full of AI

In order to make the best possible use of all knowledge of AI in Amsterdam, knowledge institutes and the municipality are working together closely. Every organisation contributes, each with a slightly different focus. What are these 9 organisations and how do they work together?

Amsterdam Economic Board

The Board collaborates with various companies, educational institutions, and governmental organisations. In doing so, it promotes collaboration as an independent player between the parties.

Amsterdam Economic Board

City of Amsterdam

The City of Amsterdam encourages the use of AI in the city with 7 AI developers and 25 interns. With 277 start-ups, the Amsterdam region is the largest AI start-up magnet in the Netherlands.

Gemeente Amsterdam

Netherlands Cancer Institute

At the Netherlands Cancer Institute, 8 professors are working on research in which AI and oncology overlap. For example, a project is underway to improve the analysis of medical images.

Sanquin

Blood and data are the source of the activities at Sanquin, the leading expert in the field of transfusion medicine, immunology, and (immuno)haematology. Innovation through scientific research is crucial.

Sanquin

ANTONI VAN LEEUWENHOEK
NEDERLANDS KANKER INSTITUUT

VU University Amsterdam

Within the VU, AI has been incorporated in four programmes. In addition, an estimated 80 PhD students and 20 professors work in different areas of AI, from law to robotics.

VU VRIJE UNIVERSITEIT AMSTERDAM

AI students in Amsterdam
The UvA, the VU, and the AUAS

Total of **6,868** students

- Bachelors of Artificial Intelligence — 496
- Masters of Artificial Intelligence — 424
- Other bachelors with courses in AI — 1.156
- Other Masters with courses in AI — 1.002
- HBO minors with courses in AI — 600
- HBO programmes with courses in AI — 3.190

ICAI labs

- AIM Lab
- Delta Lab
- AIRLab
- The Elsevier AI Lab
- Atlas Lab
- QUVA Lab
- CAIL
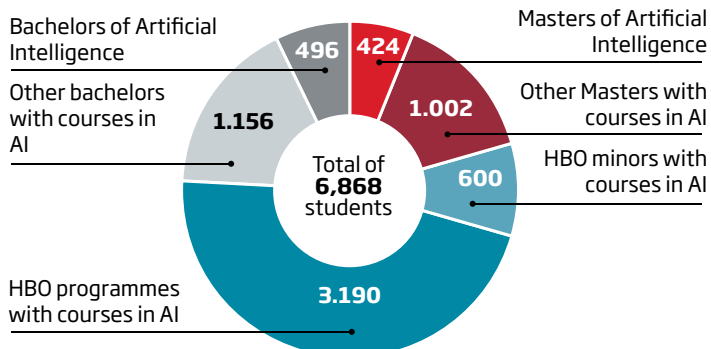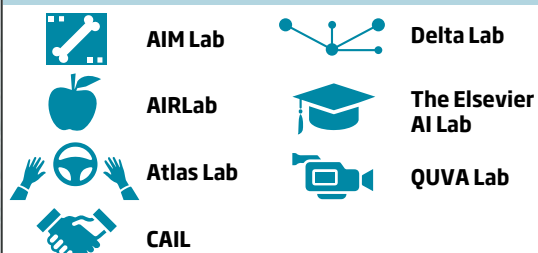
Areas of expertise in amsterdam: AI and...

94

Number of professors providing AI-related education and research.

PSYCHOLOGICAL DATA-DRIVEN
CLINICAL METHODS INNOVATION
EPIDEMIOLOGY **STATISTICS**
COLLECTIVE
DECISION-MAKING SOCIAL ROBOTICS
DATA HEALTH CARE LOGISTICS BUSINESS
VISUALISATION LAW AND ANALYSIS
INFORMATIONAL DIGITAL TECHNOLOGY VISUALISATION
SYSTEMS ALGORITHMIC FINANCIAL
LINGUISTICS DATA ECONOMETRICS
NEUROTECHNOLOGY
COMPLEX GENETICS URBAN
ANALYSIS

■ Mathematics ■ Medical ■ Business administration and economics ■ Other

CWI National Research Institute for Mathematics & Computer Science

At CWI, 15 group leaders and professors, and 52 PhD students in 8 different research groups, work on 56 AI projects. The CWI works together with the Board, the UvA and the AUAS, among others.

CWI
Centrum Wiskunde & Informatica

University of Amsterdam

The University of Amsterdam has a wide range of programmes that cover AI, including psychology, software engineering, and mathematics. There are 29 professors working on AI-related education and research.

UNIVERSITEIT VAN AMSTERDAM

Amsterdam University of Applied Sciences

A new centre of expertise was set up at the Amsterdam University of Applied Sciences in January 2020: Applied Artificial Intelligence. Here, they are working in co-creation with the research groups and external partners.

Hogeschool van Amsterdam

Amsterdam UMC

To improve healthcare, Amsterdam UMC uses AI-driven technologies. This makes better use of complex medical information, including for decision-making. In addition to many bioinformaticians and data scientists, there are 9 professors working on AI.

Amsterdam UMC
Universitair Medische Centra

1 km

ai technology for people

Brains that remain

There is a *war on talent* raging within the field of AI, with young researchers being lured away by big tech companies. Yet there are also talents who consciously choose an academic career. Two professors and two rising stars talk about their work.

Text: Ans Hekkenberg

LEADING BY EXAMPLE

Cees Snoek is Professor of Intelligent Sensory Information Systems and Pascal Mettes is Assistant Professor at the Institute of Computer Science, both at the University of Amsterdam.

BOB BRONSHOFF

Cees Snoek

Pascal Mettes

What are you working on?

Pascal Mettes: 'We ensure that artificial intelligence is able to recognise objects and behaviour in videos. What or whom do you see in the video, with what object, what are they doing?'

Cees Snoek: 'If AI can interpret videos correctly, there are all kinds of applications that can be imagined. For example, AI can assess medical scans. But you can also think of cameras at Schiphol that monitor what happens to your suitcase. And we are working with TomTom, for example. There are TomTom cars driving around capturing the area. With those images, we create advanced maps for self-driving vehicles.'

What makes this field challenging?

CS: 'AI works on the basis of machine learning. If you show a learning system what a tree looks like a hundred times, the software can learn to recognise trees. We try to encapsulate that learning process in algorithms.'

PM: 'The old strategy was to impose rules on a system. Suppose you have a camera system in a nursing home that monitors if

someone has fallen. Previously, you would tell that system: if someone is lying on the floor in his or her room, they have fallen, and you have to warn the staff. But practice is more complex than that. Hard rules won't get you anywhere. What we do now is to give a computer examples of images and their correct interpretation. The machine itself learns to take the step from image to comprehension.'

CS: 'This is how we ensure that AI can assign meaning to pixels.'

Why do young talents choose this field?

PM: 'When I started seven years ago, it was a field of ideals. We wanted to do a great deal, but we weren't there yet. Over the past few years, development has been moving at breakneck speed. The example of that tree? Seven years ago, we barely knew how to do it. Now that's an easy job. It's nice to work in a field that's changing so fast.

Is it hard to find people for this research?

CS: The industry attracts many people, so we run into difficulties when talents choose the academic world. People like Pascal are hard to find. But the more you can attract such talents, the more other young people you attract. They see the great opportunities that lie here.'

CUSTOMISED SEARCHING

Maarten de Rijke is University Professor of AI and Information Retrieval and Harrie Oosterhuis is a PhD student at the Information and Language Processing Systems Research Group, both at the University of Amsterdam.

What is the core of your work?

Maarten de Rijke: 'We research how, for example, search systems and recommendation systems can learn from user behaviour.'

Harrie Oosterhuis: 'These systems search large collections of, for example, websites, films or products. They have to show a selection that meets the needs of the user. By keeping track of what people click on, what questions they ask, and how quickly they make choices, such a system can learn to do that better and better.'

What makes the task of a search engine complex?

MdR: 'Each action by the user provides the system with additional information. So, it's a constantly changing issue. Moreover, users have different needs at different times. Suppose someone always reads the same genre of books. But one day that user is searching for a gift for someone else. A search system must be able to deal with unexpected signals like that.'

HO: 'Another challenge is if several people use the same account. You watched *Stranger Things* on Netflix; your kid watched

Maarten de Rijke

Harrie Oosterhuis

BOB BRONSHOFF

Peppa Pig. If the system doesn't understand what's going on there, it's going to offer very strange suggestions. A smart interactive system understands the situation and doesn't suggest children's programmes after bedtime.'

Why does this require artificial intelligence?

HO: 'In his lectures, Maarten compares a search engine to a librarian. On the one hand, they know which books are available, and, on the other hand, they understand what you are looking for. Even if you don't know it yet. In such a role, you have to make decisions based on countless uncertain factors. That's too complex for programmes that follow simple rules. That takes AI.'

MdR: 'What is also crucial is that AI learns from new information through user interactions and can improve a search engine.

How does a machine like that learn?

MdR: 'Recommendation systems some-

times add strange suggestions to the results. This is deliberate: the system is testing to see whether you are interested in something other than your usual choices. That's how it gets to know you better.'
HO: 'Say, someone is looking for recipes. If the system always suggests Italian food, it would seem that this person thinks pasta is the perfect food. But if the system had suggested stew, it might have discovered that the user likes that even more.'
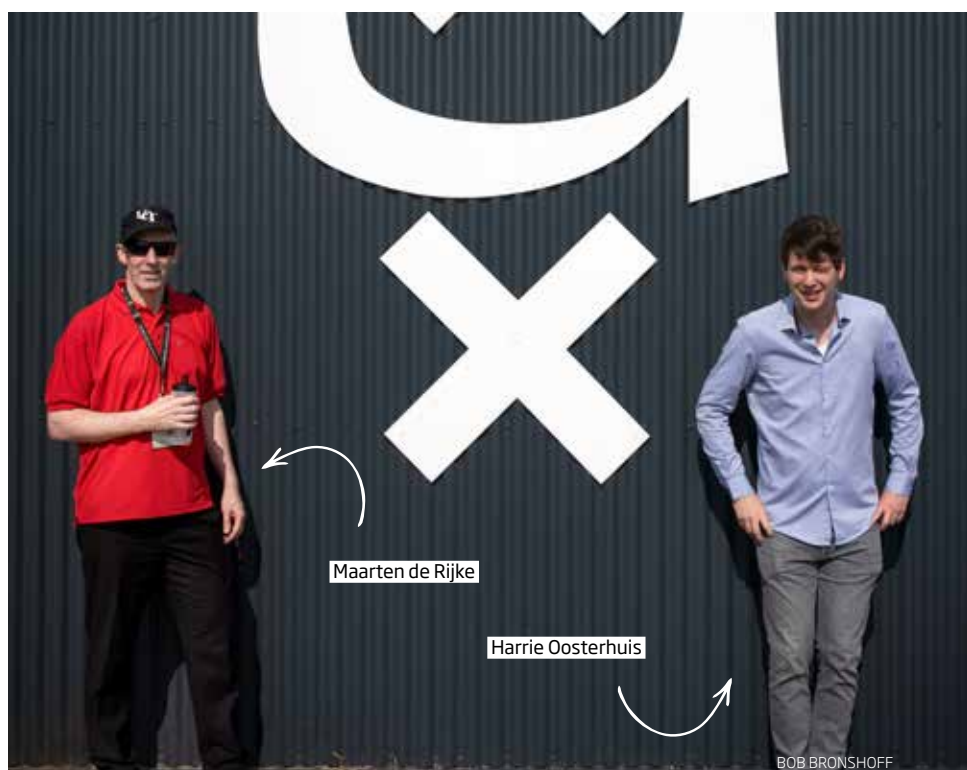
How do you get your work out into the world?

MdR: 'We work with companies that use search engines and recommendation systems, both with large organisations such as Google, bol.com, and Albert Heijn, and with small parties such as grocery stores. That makes this field interesting. As a researcher, you have one leg in the academic world and one leg outside of it. That gives you inspiration and requires a special kind of talent.' ■

THE DIFFERENCE BETWEEN CANCER AND NO CANCER

Can artificial intelligence help in the fight against cancer? In order to study this, the University of Amsterdam and the Netherlands Cancer Institute (NKI) have joined forces. They are starting a new lab within the Innovation Center for Artificial Intelligence (ICAI). One of the scientific directors of the lab, Jan-Jakob Sonke, and ICAI Amsterdam director Marcel Worring share their expectations.

Jan-Jakob Sonke

Marcel Worring

What do you want to achieve with the new lab?

Jan-Jakob Sonke: 'We want to use AI to improve cancer treatments.'
Marcel Worring: 'The UvA has the AI expertise. The NKI has the necessary knowledge about oncology. Bringing that together will give this research an important impulse.'
JJS: 'There are several topics to which AI can be applied. For example, understanding cancer at the cellular level. But also when deciding which therapy works best for a patient. And to find out what complaints a person can expect after treatment. Certainly in the beginning, however, the focus will be on image-driven therapy, which is my expertise. By analysing the image of a tumour, you can determine very precisely what should be irradiated or cut away, and what should not. AI can do that image analysis very accurately.'

How can AI properly assess an image of tissue?

MW: Before the advent of AI, we tried to encapsulate as much knowledge as possible in rules and had a computer program perform analysis on the basis of that knowledge. Over the past ten years, we have learned to let a system decide for itself what those rules are. You give a system many examples of images and tell it: this is cancer, this is not. AI can then independently find out what the characteristics are of an image with cancer. This method has proved to be much more successful.'
JJS: 'AI can already identify pictures of dogs or cats. But scans of cancer patients are more difficult. The differences are more subtle – small details make the difference between cancer and no cancer.'

Is AI already used in patient scans?

JJS: 'It happens in an experimental sense, but in practice it isn't routine yet. The goal is to get our algorithms to such a level that they can actually be used for the treatment of the patient. I foresee that we will be able to put some developments into practice within five years.'

Do you expect a great deal of knowledge exchange with other AI labs?

JJS: 'Certainly. Take self-driving cars. There, too, AI has to analyse images and make a decision: turn left or right? We want to do something similar for irradiation and operations. We want to continuously take live images of the tumour and use them to make adjustments during treatment, so that you radiate or operate in the right place.'

How will the lab develop in the coming years?

MW: 'The combination of high-quality AI and oncology expertise makes this lab a unique place. The aim is that the lab will make even more cross-pollination possible in the future, also with other parties in Amsterdam. ■

'Health care providers' notes contain incredibly rich data'

Piek Vossen

BRAM BELLONI

Marike van der Leeden

Text: Fenna van der Grient

I t is obvious that COVID-19 causes a great deal of damage to the body. But a lot is still unknown about recovery after the disease, while this knowledge is invaluable in helping patients convalesce properly.

Professor of Computational Lexicology Piek Vossen (VU University Amsterdam) and convalescence researcher Marike van der Leeden (Amsterdam UMC, location VUmc) are charting this recovery process.

There is a whole mountain of information available, in the form of notes that doctors, nurses, and other care providers include in patient records. Using text mining, a form of artificial intelligence, Vossen and Van der Leeden are trying to discover patterns in these records.

Vossen: 'From the notes made by healthcare providers in electronic patient records, we are trying to deduce what the functional status of the patients is at any given moment. We specifically look at four aspects of functioning: physical condition, the ability to walk, mood, and the ability to work or study.'

Van der Leeden: 'In fact, there is hardly any structured collection of data from COVID-19 patients. But these healthcare notes contain a lot of information. Not only from the hospital, but also in aftercare at, for example, the GP, the convalescence centre, the nursing home or the physiotherapist.'

Vossen: 'In order to extract that information, we need to interpret the phrases in the healthcare notes. Eight students are now

reading and labelling a selection of the texts. From a piece of text, they deduce what it is about (e.g. walking ability or mood) and what the patient's status is. We then use this labelled data to train an AI classification system. If that is successful, we will feed that system all the COVID-19 data we can get.'

Van der Leeden: 'In the end, we are specifically interested in the convalescence treatment of COVID-19 patients. We want to know which knobs to turn for optimal recovery. Based on that knowledge, we want to offer much more specific and person-oriented convalescence.'

Vossen: 'But we're not there yet. One of the challenges is whether it will work well for each category. For example, the ability to work is much less clearly defined than the ability to walk. Also, it is still uncertain whether we have enough data to make predictions about how recovery will proceed.'

Van der Leeden: 'We are really still in the proof-of-concept phase. But if it all works out, we can also roll this out for other patient groups that have to deal with recovery, for example after surgery or cancer treatment. It's hard, because you are dealing with written language. It's up to us to develop software that can interpret that. But healthcare providers' notes contain extremely rich data, which has not been used up to now. So, there is enormous potential.' ∎

'Hardly any data is collected from COVID-19 patients'

Intensive
intelligence

A collaboration of science, medical expertise, and business: you don't see that much within AI. A group within the AI coalition is trying to incorporate data from ICU patients into models in such a way that doctors can make better decisions about treatment.

Text: Marleen Hoebe

The data of patients who have received intensive care (ICU) treatment is very valuable for new ICU patients.

By looking at large amounts of data, it is easier to determine in advance which treatment will work best for a patient. A group within the AI coalition is trying to incorporate ICU patient data into models in such a way that doctors can make better decisions about treatment.

One of the collaborations within AI technology for people is the collaboration between intensivist Paul Elbers, AI scientist Mark Hoogendoorn, and Pacmed founder Willem Herter. All three want to apply artificial intelligence (AI) in healthcare, but they all look at it from a slightly different perspective. Together, they connect science, medical expertise, and business. That is something you hardly see within the area of AI. Why is that the case? And what is the reason that these men decided to bring together a faculty, a medical hospital, and a business?

'It's very complicated to make a model truly implementable'

Paul Elbers
Intensivist, Amsterdam UMC, VUmc location, Leader of the collaboration

'The data of ICU patients forms the basis for our project. Using this data, we can use AI to develop models that predict, for example, how likely it is that a patient discharged from the ICU will eventually have to return to the ICU. We already have a readmission model and it is available in the hospital – but only for research purposes. We hope to be able to implement it quickly in the clinic so that the model can support doctors in the decision to dismiss someone from the ICU sooner if it is safe to do so or later if necessary. This can increase both the quality and the capacity of the ICU.

Other models that we are now creating examine which treatments give the best results. For example, which medication works best, or which manner of artificial respiration is better. And we have many other models that are in the early stages of development. We're not the only ones developing these kinds of models. Huge numbers of models are being developed. As a medical specialist, I now only use one actual model on patients; only 1 percent of all models developed reaches the clinic. This is because it is very complicated to make a model truly implementable in the clinic. The model must perform well, be certified, be well integrated into the electronic health record, and contribute to better health at lower cost.'

'We need everyone's expertise in every step of the process'

Mark Hoogendoorn
Senior lecturer in Artificial Intelligence, VU University Amsterdam AI research

'Before I start working with my research group to create a predictive model for healthcare, doctors like Paul first try to define for us what we need to look for in the data of the ICU patients. Then we will look at how to apply machine learning [one of the research fields within AI, ed] for that specific problem in healthcare to create a predictive model. We research which model works best or how we can improve

technologies in such a way that we can make better models than with existing technologies. It's not surprising that our models aren't used in the hospital just like that – you have to meet strict requirements before you can actually use a model in healthcare, and this also requires many iterations with the medical experts. Of course, this makes perfect sense, but it does make it more difficult to implement a model directly.

Pacmed, Willem's company, tries to get the results one step closer to practical use than my research group. Pacmed actually creates the software for a hospital. Now it may sound like we discover something and Pacmed elaborates on it, but there is a lot of overlap. We need everyone's expertise in every step of the process. It's about cross-pollination. And that's the strength of this collaboration, I think.

Developments within machine learning are needed in order to be able to create new developments. Certain technologies within machine learning are not developed enough yet. We certainly can't solve all the problems yet. For example, some models require an awful lot of data. We want to change this; we want to develop techno-logies that reduce the amount of data required to get a good model.'

'For the final decision, the doctor remains indispensable'

Willem Herter
Founder of healthcare software company Pacmed, Development of algorithms and software

'A lot of attention is being paid to research into the use of machine learning in health-care. Machine learning is very promising; with machine learning, computers can recognise patterns in the characteristics of a patient and treatment from large amounts of data and associate them with a possible outcome. On the basis of this, decision support software for the health-care sector can be developed, which can serve as an additional source of informati-on for the doctor. However, this informati-on must be presented to the doctor in a useful and safe way. Collaboration with the healthcare sector is essential for this. That is why we are very happy with our collabo-ration with Paul and his colleagues. In addition, Mark and his research group have been an enormous help in the scienti-fic validation of our methods.

Our ICU software is CE certified, and may, therefore, also be used in the clinic. Designing software and documentation that meet the requirements of CE certifica-tion is an important step and takes a lot of time and money. Very little other CE-certi-fied machine learning software is available in the ICU. Much of the research done into machine learning doesn't result in practi-cal use, and, ultimately, doesn't reach the patient.'

We believe it is important to present the information in our software as transparent-ly as possible. Doctors, therefore, receive a substantiation of the predictions shown by the software, and, in this way, they can place the information within the entire context of the patient. It always remains the case that the data on which the algo-rithm is based does not reflect the full situ-ation of the patient. For the final decision, the knowledge and skills of the doctor remain indispensable.' ∎

ai
technology
for people

TATA

KLM

ORACLE

adyen

digicom Lab
roeters eiland

TNW

Amsterdam School of Data
weesp str

Knowledge Mile

Sanquin

VU
UNIVERSITY
AMSTERDAM

Amsterdam
UMC

Amsterdam
Life Sciences
District

BOSCH
Invented for life

gsk

Infosys
Navigate your next

Microsoft

amazon

responsible use of data a

'For us, the **focus** is always on the **human being**'

What do you need if you want to solve the practical problems of governments and companies with the help of AI? Revolutionary algorithms, expensive hardware, large dataset? Not at all. AUAS's brand new Expertise Centre Applied AI operates according to a much more important core principle.

Text: Sebastiaan van de Water

Dozens of shapes move through the image. People, pigeons, and vehicles criss-cross each other's paths. An artificially intelligent algorithm analyses the video recordings of the scene, with one goal: to count how many people get in and out of taxis here at Amsterdam Central Station. The AI's skills are beyond question. Using millions of examples, it has taught itself, under supervision, to recognise moving people and cars flawlessly. But confronted with the chaos of Amsterdam Central Station, including passing cyclists and screen-filling trams, the AI begins to stutter. Ten people just got out of one taxi at the same time, the algorithm reports.

Nanda Piersma cites the anecdote with a smile. For the scientific director of the Expertise Centre Applied AI (ECAAI), it is no longer news that algorithms that work well enough in a 'clean' and controlled setting to extract academic promotions can sometimes stumble in unpredictable urban environments. 'That in itself is understandable,' she points out, 'but if we want to share the fruits of the AI revolution with society as a whole, it is crucial to make that last translation as well. To concrete applications of AI that local businesses,

governments, and citizens can actually work with.'

The ECAAI of the Amsterdam University of Applied Sciences (AUAS) has an edge in this vital task, thanks to its deep roots in the practical world. Piersma: 'Academic institutions conduct pioneering research; we build useful applications. That is why collaboration in Amsterdam is so important. If we create an AI to analyse the

'Revolutionary AI and applicable AI are two totally different things'

structural strength of Amsterdam's bridges and quay walls, that really doesn't have to result in PhDs. Above all, it should prevent those structures from collapsing. Revolutionary AI and applicable AI are two totally different things, but they need each other.'

Co-creation

What is essential for building practical AI is demonstrated by the way the seven different AI Labs (see text box) of the ECAAI work. Companies or other parties can develop in co-creation §solutions to the issues they are struggling with, with experts, programmers, and students in any

lab. For example, the legal tech lab works closely with ARAG, a legal aid provider, to train algorithms that can assess whether a battle for higher severance pay is a good idea. Together with ZiggoVodafone employees, the Responsible AI lab is trying to improve the AI that can see from a photo of the meter cupboard whether a mechanic is needed to install Ziggo's decoder. 'That can save a lot of frustrating customer service calls. Research has shown that customers regard this as the most important irritation factor,' says Katrien de Witte, Operations Director of the ECAAI.

Co-creation is the absolute core principle within every AI lab, Piersma emphasises. 'We don't write algorithms off the cuff just because they seem brilliant. We listen closely to the people in the field. They are the experts on the ground and understand best where the practical problems lie. So, when it comes to healthcare issues, we work with nurses. When it comes to garbage disposal, we stand side by side with the garbage collector. That's what we mean by co-creation.'

The scientific director knows of plenty examples of ingenious solutions that do not work in practice due to poor co-creation. Like the smart respirators. These high-end devices have sensors and algorithms that allow them to accurately measure how much breathing support an ICU patient needs. This is an excellent innovation, as
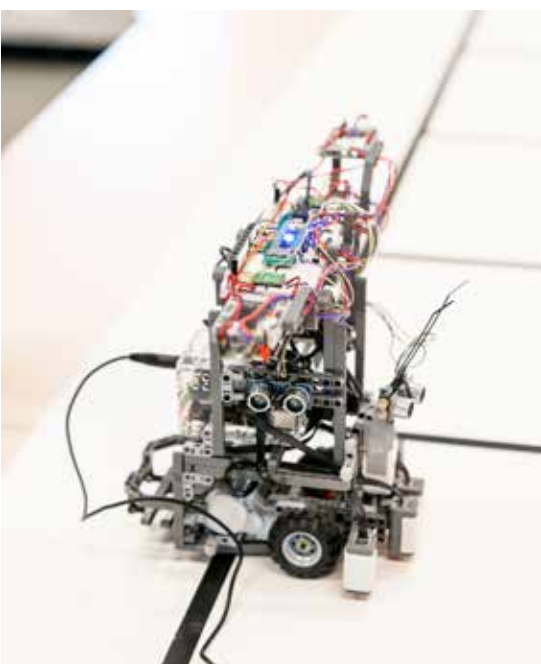
Katrien de Witte

Nanda Piersma

BRAM BELLONI

The time when only students from technical programmes have to deal with AI is over.
BRAM BELLONI

The seven labs of the ECAAI

The ECAAI of Amsterdam University of Applied Sciences comprises seven different AI labs. These offer experts, students, programmers, companies, NGOs, and governments the opportunity to use AI and data science to create practical solutions to practical problems.

Each of the seven labs is linked to a faculty of the AUAS and, thus, has its own field of specialisation:

Lab Specialisation
- Finance Lab - Finance & accounting
- Legal Tech Lab - Legal practice
- Responsible AI Lab - Public & creative sector
- Smart Education Lab - Education
- Smart Asset Management Lab - Technology and smart maintenance
- Smart Health Care Lab - Healthcare
- Centre for Market Insights - Marketing & retail

complete assumption of the respiratory function can leave a patient severely weakened over time. Several Dutch hospitals have, therefore, purchased these smart respirators. Piersma: 'But what do we see in practice? Doctors and nurses in the ICU turn off the smart feature. They don't trust it when suddenly there is hardly any oxygen being supplied. Does the patient really no longer need oxygen, or is the device faulty and is the patient dying? Because the perspective of the workers was not taken into account sufficiently during development, there is a lack of trust in the AI and its impressive capabilities remain untapped.

Social robot
The Centre for Market Insights, one of the seven AI labs, is proving that things can be done differently. The CMI has focused on a common problem: the deterioration of shopping centres. Brick-and-mortar shops are losing the battle with online shopping and the vacancy rate is increasing throughout the country. 'Ideally, shopping centres would develop into areas of experience,' says De Witte, 'where you go not only for a T-shirt and a box of oatmeal, but to experience a special day.' Sounds good, of course, but what exactly is needed for that transformation?

One possible solution lives at the Wibauthuis, the main building of the AUAS. Sometimes you will meet her in the corridors: a white, smooth, 120-centimetre-long entity. Anyone who wants to can start a conversation with her, because Pepper is considered the world's most advanced programmable social robot. Thanks to an arsenal of sensors, she can recognise human emotions and respond to

'Soon all 55,000 students here will be AI-ready in terms of knowledge and mindset'

them. AUAS purchased Pepper to experiment, together with retailers, with possible roles that robots could play in shops in the future, for example, as a mobile helpdesk, or as a corona-immune host, or child-friendly attraction. 'The retailers are involved in every step of the project chain,' says De Witte. 'So, they won't get a talking robot in their shop that they eye with suspicion.'

Suspicion and scepticism are always stumbling blocks on the road to the smooth implementation of artificial intelligence, ECAAI's director duo knows. In discussions with parties from the construction sector, healthcare, and education, they sometimes notice strong resistance and fear. Algorithms and robots might take away jobs and dehumanise work.

Co-creation can put an end to that fear, Piersma believes. 'For us, the focus is always on the human being. For example, together we will discover how AI or Data Science can help employees on the floor to spend less time on 'robotic' tasks, such as administration, thereby freeing up time for individual attention to pupils and patients. Artificial intelligence can humanise our society. That awareness helps organisations to become AI-ready.'

Smart rugs

Nanda Piersma herself has been AI-ready for decades. She grew up on a diet of science fiction books and series. 'Anyone who works with Nanda for some time will automatically look at the world through an

optimistic AI lens. Soon you realise there are still so many untapped possibilities. Although she is sometimes a few steps ahead of me', De Witte admits. Where one person would find a smart vacuum cleaner interesting, Piersma is already thinking about smart rugs that automatically remove dust and crumbs. 'Believe me, we are only at the beginning of the AI revolution,' says Piersma. She points to a table in the Leeuwenburg, on which a Lego robot is driving. Programmed by AUAS students. 'The time when only students from technical programmes have to deal with AI is over. Based on the experiences in the labs, we want to upgrade all programmes, so that soon all 55,000 students here will be AI-ready in terms of knowledge and mindset. All the professions we train them for will change under the influence of AI. There is still a lot to be gained. And if we continue to put AI at the service of people, instead of the other way around, it will be a very nice and interesting world.' ∎

column

Real lives

What could be better than using data collected during the first wave of COVID-19 to reduce the chance of infection in a second wave, or to improve the treatment of patients in that second wave? That is what we are trying to do with artificial intelligence (AI). With AI, we have designed an algorithm that can determine the optimal medication dose for each patient. The dose that helps, with the least side effects, at the lowest cost.

With AI, we are creating software that helps to read MRI scans so that we can quickly and easily make a diagnosis and predict whether treatment is useful. And an algorithm that reduces the time a patient has to spend in a scanner, so you can have the same quality of images in a much shorter time, and can, therefore, help more patients.

That, as a heart patient, you can call a telephone number where someone can see your ECG in real time in case of complaints. And vice versa, that you as a patient are called spontane-

ously, before you notice that something is wrong with you.

Unlimited opportunities and possibilities! And what is necessary to make that happen? Data, of course, a lot of data, of good quality, of a lot of patients. And, above all: people who work with that data, who work together. From multiple disciplines, from multiple institutes. Experts who always realise that there are real lives hidden behind that data. AI for people. This is what Amsterdam UMC wants to do in the coming years. To cure patients, to keep healthy people healthy.

Chris Polman
Amsterdam UMC, Chairman of
the Board of Directors VUmc

'We look at whether education policy really contributes to equality of opportunity'

Text: Fenna van der Grient

Unfortunately, our society is not yet free of inequality and discrimination. When you develop artificial intelligence in such an environment, you have to be careful that algorithms do not copy this inequality. Neuroinformatician Sennay Ghebreab (University of Amsterdam) is committed to AI technology that safeguards values such as equality and privacy. And he goes one step further: he develops artificial intelligence to promote equal opportunities in Amsterdam.

'We are developing AI technology to, on the one hand, expose the chance of inequality in the city and, on the other hand, to promote equality of opportunity. To this end, we have set up the Civic AI Lab, a collaboration between the UvA, the VU, the City of Amsterdam, and the Ministry of the Interior. The lab is part of *the national Innovation Center for Artificial Intelligence (ICAI)* and has the ambition to be a leader in societal applications of artificial intelligence. In collaboration with the City of Amsterdam, we will tackle problems in various domains: education, healthcare, welfare, mobility, and environmental factors. Together with the Ministry, we are looking at broad scaling up of government applications and research findings.

In the field of health, for example, we are looking at the first thousand days of a child's life. These first thousand days influence life expectancy, the risk of illness, but also the position in education and the labour market. Not all children have the same chance of a healthy start in life. There many factors that affect the future: socio-economic factors, where you grow up, health, communication with parents, and parents' love.

We work together with various parties regarding pregnancy, birth, and youth healthcare. They have collected a lot of data. We want to use *machine learning* algorithms to see how we can integrate these data flows in Amsterdam and the surrounding areas. We hope to be able to use that to extract predictive factors. We do this with respect for fundamental human rights such as non-discrimination, equality, and privacy. This means that the algorithms we develop take into account differences in gender,

'We hope to extract predictive factors from data streams from Amsterdam and the surrounding area'

race, etcetera, but include them in an honest way in the analysis of the data. This is how we are working towards recommendations to improve equality of opportunity.

Another project we are working on focuses on education in Amsterdam. Money is available from both the central government and the City of Amsterdam to eliminate educational disadvantages and inequality of opportunity in primary education. But the question is, of course, which policy really contributes to providing the best opportunities for all pupils. Money has been made available, but is it arriving in the right place, and is it having any effect? Using AI technology and smart data analysis, we look at whether it really contributes to equality of opportunity, and if not, how we can improve that.' ∎

Sennay Ghebreab

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'A patient is not a package'

Two years ago, Professor of Elderly Care **Bianca Buurman** had trouble imagining that AI could be meaningful to her profession. Now that she works with mathematician **Rob van der Mei**, she knows better.

Text: Kees van Unen

t is a weekday morning at Amsterdam UMC, location AMC, and Rob van der Mei is waiting by the lifts. There are two of them: one that only goes to the first two floors, and one that only stops on the third floor. And it's things like that that add a twinkle to his eye. 'See,' he says, 'this is quite a step in the reduction of waiting time. But there's a lot more you can do. For example, they could programme the lifts in such a way that in the morning – when people come in and have to go to their workplaces – they return to the ground floor by default. And at lunchtime and at the end of the working day, they always go halfway up or to the top. You should see how much time that would save.'

Welcome to the brain of Van der Mei, senior researcher at the CWI National Research Institute for Mathematics & Computer Science and Professor of Applied Mathematics at the Vrije Universiteit Amsterdam. He previously made a leap in efficiency by calculating how ambulances could arrive at the scene of an accident sooner. This was done on the basis of models that were able to show where there was the greatest chance of an incident at

that time, and the proactive deployment of ambulances in response, instead of waiting at a fixed location. It worked, and that's quite something in a situation where every second can count – lifesaving in many cases. And, for Van der Mei, a wonderful example of mathematics in practice.

Van der Mei exits the lift – which came quickly by the way – and walks towards the office of Bianca Buurman, Professor of Acute Elderly Care at Amsterdam UMC, Professor of Transmural Elderly Care at AUAS and a former nurse. Someone who knows the practice, and with that knowledge is now structuring the organisation.

Recently, they were introduced to each other to see what Van der Mei's field – mathematics, big data, and, since a few years, also the application of AI – can mean in elderly care, where logistics has a lot of room for improvement. Those cursed waiting lists, for example. And the optimisation of processes in elderly care can be seen from many perspectives.

Bianca Buurman: 'What is really new for us, for example, is logistics that is not limited to a single hospital but that covers all healthcare chains.'

Rob van der Mei: 'A macro model, then. I try to visualise it in such a way that the

'The theory takes on a new dimension, because it's all about people'

patient is walking through the system, from first aid to general practitioner, past the municipality to a nursing home. And they can get stuck or stumble upon waiting times anywhere.'

BB: 'By zooming out – and not just looking at each link in the chain, but at the chain as a whole – you can plan much more effectively. In that respect, we can learn from systems like that of bol.com.'

RvdM: 'We can learn from that, yes, but the difference is: a patient is not a package. A package can't talk, has no will of its own, no family with an opinion. That is much easier to plan, of course; you can apply relatively simple mathematical optimisation to it. Because it involves people, the theory takes on a new dimension. It's not just logistics but also feeling, which makes it more complex but also more fun for us. Because package a is equal to package b, but patient a is never equal to patient b.'

BB: 'That's why, in healthcare, we tend to look at the person, and not or less at the big picture. But sometimes looking at that big picture can offer the most humane solutions in the long run. A lot of what goes wrong concerns the lack of capacity, the waiting periods – especially since the reduction of the number of beds in nursing homes starting in 2015. Patients get stuck in the system and problems accumulate. It would help enormously if we could predict those moments when people are in danger of getting stuck – for example, when they need a bed in a nursing home – and, therefore, be able to respond to them sooner.'

RvdM: 'Like the ambulances. With AI technology and big data, we might be able to see it coming. This is difficult for individuals, so it would automatically involve the entire system. For example, by working with a waiting list system that connects to the idea that you are always in the wrong queue, so instead of one, connecting to three rows at once. Then the shortest waiting time of three rows is always yours. That sounds simple – of course it's more complicated – but it can be very effective.'

BRAM BELLONI

Human contact

BB: 'Care will always be human, but it is precisely by making the system more efficient and using data and new technologies, that I hope we can retain that human touch. Without the technology taking over, as would be possible in certain aspects of the medical profession – surgery, for example. But somebody who needs to be washed, that's human to human.'

RvdM: 'I can't imagine a robot at your bedside instead of a nurse.'

BB: 'It was precisely during the period of corona that some of that human contact was lost, for example, because no visitors were allowed in nursing homes. Technology took over contact, but you can still see that people need physical contact. But with technology, we can now look at how busy it is and make visits as safe as possible.'

RvdM: 'Care is by definition something human, you can never take that away. So, the gains lie in efficiency, making sure the

'We can learn effective planning from systems like that of bol.com'

chains run smoothly. It will never work completely, but in the end the goal is a world without waiting times.'

BB: 'Two years ago, the application of AI and big data in healthcare was still a long way off. I thought, what can you do with that? And also: mathematicians, what kinds of people are they? But now I see how we can use it to change the practical side, even to improve it.'

RvdM: 'You can do a lifetime of scientific research and limit yourself to publishing in scientific journals. But I would like to go a step further and use my knowledge where it is really needed in practice: here. That's when it really becomes fun.' ∎

'Search for depth in the conversation about technology'

BRAM BELLONI

Natali Helberger researches the social, legal, and ethical consequences of AI. 'I would have expected some more parliamentary discussion concerning the regulation of technological measures against corona'

Text: Wim de Jong

At the beginning of March 2021, there is a big fuss among the more fanatical wing of CDA supporters. What is going on? Just before the Dutch Parliamentary elections, charismatic party leader Hugo de Jonge committed a slip of the tongue that even Joe Biden would not have made. 'As Jesus would say, don't pin me down on it,' he said in a respected talk show. The ultra-short but oh-so-explosive fragment spreads over the internet like an oil slick. The indignation is great – not least of De Jonge himself, who claims never to have made the statement.

Implausible story? It may sound strange, but something similar really happened. CDA supporters have indeed become angry for a misplaced statement by a prominent politician of their party. The difference with the scenario above is that they participated in a study by Natali Helberger, university professor of Law and Digital Technology at the University of Amsterdam. In the study, it was not De Jonge, but Sybrand Buma who made the statement – in a deep fake: a video doctored with the help of AI.

With the experiment, Helberger and co. not only wanted to find out whether the voters would fall for it and lose confidence in 'their' politician, but also whether this effect would be enhanced if the images were mainly shown to a specific, more sensitive target group: microtargeting. The amplifying effect of microtargeting turned out not to be that spectacular. 'But I did worry about the number of people who thought it was real,' says Helberger. 'People apparently have great faith in moving images. Deepfake is, therefore, a pretty effective tool for deception. We were quite proud of our video, but it wasn't really a very good deepfake. And, as the technology improves, probably within a few years,

it will become very difficult for a non-professional to recognise whether a video is fake.'

Should we now fear that the VVD will actually distribute a doctored video in order to bring down the competition? 'I hope that the Dutch democratic system is solid enough that parties will not resort to such measures. I think you can expect people to do it for non-democratic purposes, to undermine. Think, for example, of foreign interference, or individuals who want to cause trouble, they exist – yes, also in the Netherlands.'

Corona app

That the rise of AI is important for the elections has been made more than clear, but politics will have to relate to it in other ways as well. Just think of the privacy issues that a corona app raises. And that is exactly the kind of topic Helberger deals with on a daily basis. As a professor of information law, she studies the legal, ethical, and policy challenges associated with the use of algorithms and AI in media, political advertising, commerce, and the health sector, and the implications for users and society. Perhaps she can give voters interested in AI – and that should be all of us – a few insights to prepare them before entering the polling booth in March.

In April, she sounded the alarm with a number of fellow scientists: we should take a critical look at that corona app, they wrote in a letter to the Lower House. 'It was only about whether the app should be created or not. The question was never: what's the real problem? Which technological solution is the best fit? What more do we need to make sure the technology really works the way we want it to? A second point we made is that contact tracing, or any digital solution, interferes with fundamental rights. All the more reason to weigh carefully what the purpose is, and what the role of the law is to ensure that fundamental rights are safeguarded.'

In any case, there should be more parliamentary discussion on this subject, says Helberger. 'The proposal for the corona act led to an unbelievable amount of discussion just before the summer. Strangely enough, the provisi-ons on technological measures in the act have hardly been discussed'

In response to the letter about the corona app, Helberger was asked by ZonMw, an organisation for health research and care innovation that works closely with the Ministry, to write a study on the legal, social, and ethical implications of digital technology. 'We are also developing a monitoring tool to measure how people use the app and what possible social consequences the introduction of the app could have. Think, for example, of stigmatisation in the sense of social exclusion of people who have tested positive, or of people who refuse to use the app, or that employers won't let you in if you haven't downloaded the app.'

Recommendation systems

Back to the future: the 2021 elections. As March 17 approaches, the flow of political news swells and hopefully we will all read the (digital) newspaper a bit more carefully in order to make an informed choice. But how do we know that we haven't ended up in a nasty filter bubble of algorithmic recommendation systems that offers us nothing but tunnel vision? If we only consume our news through Facebook, we're on the wrong track. 'Facebook is one big recommendation system. They use it mainly to show you relevant content and personalised ads.' But in the news personalisation that the media themselves use, Helberger does not immediately see a threat to democracy. 'We see that news media such as DPG Media and RTL are experimenting with news personalisation in order to provide us with targeted information and to recommend content that is relevant based on your reader profile. Usually these recommendation systems are limited to parts of the website; it is not the case that the entire Volkskrant is sud-denly personalised. More and more attention is also being paid to the responsible use of news personalisation and the effects on, for example, diversity or privacy.'

Depth

And last but not least, how do we choose the party that is most AI-ready? Helberger advises us to read the election programmes critically. 'When talking about technology, look for depth. Are the phrases hollow? Or have we really thought about the positive aspects, but also about how we can protect civil rights? It's very modern to say: we want to invest in AI, but to really think about it you have to be aware of the implications. Only then can you invest in AI responsibly. And how do parties want to deal with large American platforms that are leading in the development of the technology, and that have sole control over large amounts of data? How do we ensure that sufficient talent is developed in the Netherlands to produce good technology ourselves? How do we ensure that we stimulate innovation in Dutch companies? How do we ensure that there is sufficient funding for research into the effects of technology? With this last aspect, we have

> 'Only when you have an eye for the social, legal, and ethical implications, can you use AI responsibly'

arrived at initiatives such as AI technology for people, in which Amsterdam knowledge institutes and the municipality work together and develop initiatives to put AI on the map. 'For the Netherlands, that's super important. I am very happy that attention is being paid to the broader social interests.'

Could Helberger maybe give us a little push in the right direction for March 2021? 'No, I don't think it's a good idea to give voting advice.' Perhaps it's not so surprising: responsible handling of the implications of artificial intelligence remains primarily an issue of using our good human sense. ∎

Researchers and **discoverers**

Scientific research helps to discover – and realise – the potential of AI. Three professors about their relationship with artificial intelligence and what it could bring us in the future.

Text: Joris Janssen

MACHINES BECOME PARTNERS

Maarten de Rijke, Professor Artificial Intelligence and Information Retrieval

When did you first become acquainted with artificial intelligence?

'As a student, I became interested in the concept of information. I was curious about how you can convey information, for example, through language. For a while, I focused on 'representations' of information. Representation is the process of linking meanings to certain characters. I soon moved on to mathematics and computer science and started working with formal models. This all happened in the '90s.'

What aspects of artificial intelligence are you currently working on?

'My work is largely about information retrieval. It's all about how to bring people and information together. Think of search engines, recommendation systems, and digital assistants. They rely a lot on artifici-

al intelligence. For example, a system must understand what a human being is looking for. It must understand a search term or question, as well as the context and the behaviour of the user. So, the system has to find out whether it should show more of the same results next time – or fewer.'

Can you give an example of an interesting project you are working on?

For example, we are now working on the question of how to allow a system to act autonomously. Traditionally, a system learns from positive and negative examples. But that paradigm has limitations. What if a system does not receive enough information from the user? Then the system should think about what that user might mean and perhaps ask for an explanation. A similar issue is how to help a user to find information more effectively and efficiently – information that they might not even know they were looking for. For example, films, books, music, and online purchases.'

BRAM BELLONI

What is your role within the Dutch AI coalition?

'Just over two years ago, a number of colleagues and I founded the Innovation Center for Artificial Intelligence (ICAI) here in Amsterdam. We wanted to initiate more innovation in and with artificial intelligence in the Netherlands through better collaboration between knowledge institutes and other parties. In so-called 'labs', one or more universities, companies, government institutions, and NGOs work together. In Amsterdam, examples include Qualcomm, AholdDelhaize, TomTom, and the City of Amsterdam. In these labs, these parties work together for five years, and with at least five PhD candidates, on research questions that they draw up together. The Dutch AI coalition combines all these types of activities in the Netherlands. As director of ICAI, I contribute our activities to this coalition.'

What kind of changes will artificial intelligence bring about in the next ten years?

'Artificial intelligence is going to help improve and support decisions. People are not good at making decisions based on many uncertain factors. For example, in the medical world, safety, energy issues, and food logistics. People can reason well in contexts with a maximum of two or three factors, but sometimes hundreds of factors play a role. We won't hand over making decisions, but it's about being better informed and receiving better suggestions. Machines will become a partner in the decision-making process.'

'Artificial intelligence is going to help improve decisions'

'WE BRING HERITAGE TO YOUR HOME'

Julia Noordegraaf, Professor of Digital Heritage

When did you first become acquainted with artificial intelligence?

'As a teenager, I saw the film 2001: A Space Odyssey. In it, HAL 9000, an artificially intelligent robot, eventually takes over everything. Many people still believe in a doomsday scenario like that, in which technology wins out over humans – I don't, by the way. This film made me think about the relationship between humans and technology. In 2012, I became Professor of Digital Heritage. At the time, I saw that the heritage sector was making increasing use of artificial intelligence technologies, for making collections searchable and doing research. Since then, I've been interested in both the possibilities of this technology and the consequences – you're replacing the people who have described and interpreted this information up to now.'

What aspects of artificial intelligence are you currently working on?

'Within the Creative Amsterdam research group, we are doing research into the history of Amsterdam. For this, we use all kinds of text, speech, and image recognition technologies. An example is technology that can automatically read seventeenth- and eighteenth-century penmanship. This is convenient, because we have miles and miles of estate inventories we want to study. When someone died, a notary would write down what kind of things they had in the house. Until now, no one has gone through them entirely, because it's too time-consuming. Now you can use artificial intelligence for it. This gives you a unique insight into the lives of ordinary Amsterdammers.'

BRAM BELLONI

Can you give an example of an interesting project you are working on?

'I am in charge of the development of the Amsterdam Time Machine. This is part of a major European Time Machine project aimed at making information about heritage available on a very large scale. We want to unlock the big data of the past. I am working on the virtual interiors project myself. In it, we look at the creators of art in the Golden Age in Amsterdam and at its consumers. For example, we are reconstructing the home of a family that had many cultural objects in its home. We use technologies such as handwriting recognition. The aim is to gain a better understanding of Amsterdam's identity and how it has developed historically.'

What is your role within the Dutch AI coalition? 'Soon, a working group on culture will start within this coalition. In this group, we will be working on the role of artificial intelligence in the context of heritage institutions. In addition, the coalition is concerned with social acceptance of these new technologies. My research contributes to this by showing how artificial intelligence can be used to improve the availability of our country's long-term memory for everyone.'

What kind of changes will artificial intelligence bring about in the next ten years?

'Our ambition with the Time Machine project is to create a kind of mirror world: a complete virtual replica of our world. Think Google Earth, but enriched with the dimension of time. The ideal is that you will soon have access from your computer, or any device, to all the information that is there – even from the past. Heritage is now often something you have to visit. For example, museums, archives, libraries, heritage sites, and so on. With the Time Machine approach, we bring heritage to your home.'

BRAM BELLONI

'WE HAVE TO MAKE SURE TALENT DOESN'T LEAVE'

Max Welling, Professor of Machine Learning

When did you first become acquainted with artificial intelligence?

'During my PhD in theoretical physics, I did rather abstract research into quantum gravitation in two dimensions. It was a nice puzzle, but I didn't see myself working on it all my life. I wanted to engage in something closer to society. At Caltech, I was offered a position in a lab that was working on image analysis by computers. Machine learning – the development of algorithms with which computers can learn – plays a major role in this. I liked that so much, I carried on with it.'

What aspects of artificial intelligence are you currently working on?

'With so-called neural networks. These are multi-layered information processing systems with which you can analyse data such as image and sound. This involves a lot of beautiful maths. For his description of the quantum world – the world of small elementary particles – my former supervisor Gerard 't Hooft uses all noughts and ones that interact with each other. These mathematics can also be applied to a machine that really works with noughts and ones: a neural network in a computer.'

Can you give an example of an interesting project you are working on?

I'm working on a way to display molecules in a 'graph'. This is a structure of nodes and connections that provides information about the properties of the molecules. A molecule contains atoms that interact with each other in a certain way. It is interesting to see if you can predict which properties a certain molecule has. Suppose you want to develop a cure for COVID-19. Then you'd like to know: does this molecule bind to the virus in such a way that it becomes harmless? There are databases in which the properties of many molecules are recorded. Ultimately, the goal is to be able to search those databases for molecules with exactly the properties you want.'

What is your role within the Dutch AI coalition?

'The European Lab for Learning and Intelligent Systems (ELLIS) plays an important role in this coalition. I'm one of its founders. ELLIS is a European organisation linking research centres. One of the most important goals is to ensure that talent doesn't leave but stays in Europe. Amsterdam has also set up an ELLIS unit, of which I am the director. We do exchanges and put artificial intelligence on the map in Amsterdam.'

What kind of changes will artificial intelligence bring about in the next ten years?

'A lot of new technology is coming onto the market. For example, self-driving cars, chatbots that can have conversations, and machines that can make medical diagnoses. In addition, virtual and augmented reality is becoming increasingly important. We're all hooked up to a mobile phone now, but it's actually a clumsy thing. There will be glasses or contact lenses that will take over their role. You will be swimming continuously in an ocean of information. This also presents challenges. How do you guarantee privacy? How do you make sure that not only large companies profit from this technology? How do you prevent manipulation? These developments are changing society. Human beings' weaknesses can be exploited to achieve certain goals. We have to find a balance between these challenges and the benefits that artificial intelligence offers.' ∎

A few years ago, this was a Navy training building.
BRAM BELLONI

Accessible **tech**

Codam's programming school throws students in the deep end and searches for untapped technical talent.

Text: Tamara van 't Woud

The modern-looking building suggests otherwise, but until a few years ago the home port of Amsterdam Codam Coding College was a training building of the Navy. The barracks made way for iMac-filled halls in which a diverse group of people can follow intensive programming training free of charge. In this way, Codam wants to contribute to the enormous demand for software engineers in their own way.

Things are a little different at Codam than at other training programme providers. The only requirement is that you are over eighteen. Preparatory training is irrelevant; they find out your aptitude during a 'Piscine', an intensive selection month in which the candidates are thrown into the proverbial deep end. In this way, they hunt out untapped potential.

Someone who makes grateful use of this is Angeli (22). Due to serious physical and mental health problems, she dropped out of high school in her fifth year of pre-university education. She had no starting qualification and was not eligible to attend mainstream higher professional and university programmes. Now she's found her niche.

'I've never suited to the conventional learning system. The only subject I was really good at was maths. There I was allowed to do assignments during the explanation. That's exactly the approach they take here: you can just do it. I also get a lot of support from my classmates if I'm in bad health. Because you have to learn from each other, it creates a very good sense of community.'

What?

What immediately strikes you is that, at Codam, a lot of things are lacking: no teachers, no lectures, no semesters, no timetables, and no accredited diploma. So, what Codam does offer? A project-oriented curriculum in which students review each other's work.

The entire curriculum is gamified: students reach levels by completing projects. If you submit a project, a number of random students are selected to review your work. They can be at a higher or lower level than you. If you are at level 7, you should be able to defend your work against

CV

Corinne Vigreux
In 1992, entrepreneur Corinne Vigreux (1964) was one of the founders of the navigation software company that was to grow into TomTom. Since then she is considered one of the top women in the European tech world. A few years ago, she took a step back in her role at TomTom to found Codam. Vigreux grew up in France, in a working-class suburb of Lyon. Her mother did everything she could to allow her daughter to attend the prestigious Lycée du Parc, even though it was highly unusual to attend a school outside your own neighbourhood. Good education turned out to be the key to Vigreux's successful future. Growing up in an environment with little money and fewer opportunities was an important motivation to bring the École 42 concept to the Netherlands. With her personal foundation she makes the programme possible financially. Vigreux was appointed Officer in the Order of Orange-Nassau for her work as co-founder of TomTom.

someone at level 10 and explain it to someone with at 2.

Sayf (37) is a candidate from the latest Piscine. 'Codam is unique in the Netherlands. I would like to retrain, because I feel that as a financial employee I am at a dead end. I expect that many tasks within my sector will be taken over by technology, and I want to remain relevant. I've always worked with a computer, but I had no idea what a computer really is. Now I'm learning exactly what a computer does.'

Bar

The concept originated in France, where pioneer École 42 opened its doors in 2013. The idea of a programming course that is accessible to everyone free of charge was soon imitated in other countries. Tech entrepreneur Corinne Vigreux brought the educational concept to the Netherlands, where the first students started in 2019.

Oscar (25) was in the first Piscine. After having completed his foundation course at the hbo, he decided that that form of education did not suit him. He wanted a bigger challenge and stumbled upon Codam. 'In a regular programme, you have to deal with a fixed tempo and curriculum. I could keep up with that by doing something one day a week. Here at Codam, I can follow my own pace and the material is not offered up ready-made.'

He believes the absence of teachers does not have a negative effect on the quality of education. On the contrary: 'There's a much more serious way of looking at what you're doing. In my entire year at hbo, only once did a teacher really look at my code. Here all projects have to be checked by several fellow students. The bar here is much higher, for example with regard to the security of your code. What I would get an A for at hbo is the minimum here. It's also quite normal here to do something new once in a while. You often make a number of errors the first time, which you correct until it's right.'

One-sided software

By breaking down barriers such as tuition fees and preparatory training requirements, Codam tries to appeal to as diverse a student population as possible. According to Lisa Stamm, head of communication, this is vital in a world in which AI is playing an increasingly important role. 'If you put a problem on the table and you always let the same group of people look at that problem, you get the same answer over and over again. It stands in the way of innovation. Technology is often developed by the same people. An example is a soap dispenser that was developed by a group of white people. When they put their hand under it, the dispenser worked fine. So, it went to market and was installed in all sorts of places. But if a black person held their hand under it, nothing came out. With a diverse team, you would never have had that problem. If you have AI algorithms written by a one-sided group, you

No need to go hungry.
BRAM BELLONI

will by definition get distortions in your system, regardless of the purpose. Our way of training can help us avoid developing the future of AI in a biased way.'

At the moment, Codam's diversity policy still focuses mainly on women. In mainstream tech education, only 10 percent of the intake is women. By accepting proportionally more women for a Piscine, the school hopes to improve the male-female balance within tech education. From the selection month onward, the best are allowed to continue, regardless of gender. Stamm: 'The interesting thing is that the male-female ratio of the group that is accepted turns out to be the same as the ratio of the group that comes in at the start of a Piscine.' Men and women, therefore, perform equally well within the selection system.

They would like to scale up in the future, but for that they need to involve politicians. Stamm: 'We help students as much as we can, but as long as we are not accredited, we bear all the costs ourselves. That's why we are now in talks with the government about funding, so that we can offer our education to more students.' Because Codam is convinced that the demand for tech talents will only increase. ■

BRAM BELLONI

column

No more fainting at the blood bank

Approximately 2 percent of Dutch people regularly give blood voluntarily at Sanquin blood bank. Despite the fact that people donate blood voluntarily and regularly, every day one out of 1000 people who donate faints in one of the collection centres. This may be due to a slightly too short night's sleep, or too little drinking. The blood collection staff is constantly paying attention: is someone going pale? That is a sign that someone might faint shortly. Could we use artificial intelligence to predict sooner and more successfully whether someone will faint, and even reduce the chance of it happening? Anxiety and stress can also increase the risk of fainting. We are usually not at all aware that we are very tense or stressed. But within neuropsychology it has been known for a long time that we can measure such 'states' very early and very well, before people realise it themselves. We can even teach people to actively influence unconscious physical stress reactions. Biofeedback is the official term for this. You can train people to move from an unconscious and unwanted 'state,' such as fear, to a desirable one by measuring and visualising it. Compare it to the accelerator in the car: we can make sure we don't drive too fast because we have a meter on the dashboard that indicates how fast we are driving. In the coming years, we will study whether we can find signals in digital and infra-red video images that indicate that people have an increased risk of fainting. If that is the case, we want to develop a game that you can play on your phone before donation, when the tension starts slowly and rises, and where the purpose of the game coincides with reducing the chance of fainting. Never faint again thanks to the use of AI!

Elisabeth Huis in 't Veld
Researcher Sanquin

'Health data must remain the property of the citizen'

Text: Fenna van der Grient

All the medical insights and life-saving procedures we know are based on years of research with patients in front of us. We now have a unique opportunity to greatly accelerate medical research if we use health data in a sensible, safe, and ethical way. Jeroen Maas, Challenge Lead Health at the Amsterdam Economic Board, works with partners from the Amsterdam Coalition on the responsible use of this data and the acceleration of sensible AI applications within the health field.

'Our starting point is that the health data remains the property of the citizen. The patient must be able to decide what happens to his or her data. And if we analyse medical data in a responsible way, we can get a lot of useful information from it. For example, we know that medications can negatively affect each other. But not every combination is tested beforehand. That would be impossible, with about 5,000 different types of medication on the market. But we also have 17 million people who take these medications and end up at the doctor's when they experience problems. The data are there; it's just not accessible.'

'With access to this data, we can really start working on prevention. We can look back over fifteen years of health data. That way you can recognise the development of diseases at an early stage and find out what the red flags are. In the case of cancer, for example, this is essential. The sooner you take action, the better the chance of survival. With other diseases as well, the quicker you take action, the quicker the healing will be.'

In order to facilitate this, we need to make data accessible. We are working on this in different ways. We are working with the Amsterdam AI coalition on an integrated health data infrastructure to be able to use the data currently available. But we don't just want health data to be used safely and reliably, we want it to be possible for everyone in all sectors. With a growing team of partners, including Surf, UvA, AMS-IX, AUAS, Dexes, and the City of Amsterdam, we are also working on AMdEX – a digital marketplace for data.

BRAM BELLONI

Jeroen Maas

'Exchanging data over the internet can be a tricky business. Data easily ends up in the hands of a third party and then you no longer have any insight into what happens to it, or how often your data is resold. The idea behind AMdEX is that you make agreements as transmitter and receiver of data, about what may happen with the data. Together with the other party, you determine the rules and they are then technically enforced.'

'Public transport or aircraft maintenance data, for example, is also very sensitive. Sharing public transport data is useful to offer customised public transport. But you don't want everyone to know where you are at what time. Maintenance data of aircraft engines is very competitive but contributes to flight safety. With AMdEX, we are looking at how we can technically design it in such a way that KLM and other airlines can make use of each other's data analysis results, without ever being able to see each other's data or algorithms.'

We are working towards a future in which we use data ethically, and in which the owner – be it a patient or KLM – always retains control over what happens to the data. ∎

'In the future, as the patient, I must be able to decide what happens to my data'

'AI helps to make cancer less lethal'

Every year, 100,000 people are diagnosed with cancer. In the past, the treatment of this disease meant surgery, radiotherapy, chemotherapy, and later immunotherapy. Nowadays, the goal is to diagnose cancer earlier and earlier in the process, says Marien van der Meer, one of the three members of the board of Antoni van Leeuwenhoek (AVL). She is responsible for the organisation and operational management; one of the themes she deals with is AI.

'We are increasingly using prediction models, including AI, to determine whether there is a tumour and whether a treatment can work. By examining whether a medication can work for a patient, this patient will not receive unnecessary courses of treatment, which can be very stressful. It can also become expensive.

One of the applications of AI that is booming in this field is image analysis. In the Netherlands, all medical images are still viewed by professionals. In the future, AI will view the bulk of the images and professionals will be able to focus on images that deviate. In addition, models can indicate which images have priority. This way, doctors are supported, and patients are helped faster and better. Moreover, the data is not only analysed but also used to create knowledge. The challenge that AI technology for people addresses is the privacy and speed with which data can be shared between institutions.'

Top professionals

'I don't think my work at the AVL will ever be finished. We will always want to do the best we can in the treatment of cancer. Over the past 110 years, the AVL has constantly evolved and the emphasis has shifted. The same expectation is there for the coming years. Over the past ten years, the institute has doubled in the number of patients, staff, and budget. Now the focus is on managing this growth.

The AVL is among the top 10 institutes worldwide that combine the treatment of cancer patients with research. At the AVL, 3,000 people work together to develop new insights and treatments so that cancer will become a chronic disease. We work with top professionals who know very well what they want and are the very best in their field. The AVL is an attractive employer, with a strong image. As a top institute, we attract top talent, it's reciprocal. For the coalition as a whole, top talent in the field of AI must be properly trained, and you want to retain and be able to facilitate this top talent.' –LR

Under the heading of *AI technology for people,* leading knowledge institutions in Amsterdam commit themselves to invest 1 billion euros over the next ten years, appoint a minimum of 800 researchers, train 5,000 Bachelor's, Master's, and PhD students, have 10,000 students follow an AI minor, and develop or help develop 100 spin-offs and 100 start-ups.

Central to the coalition's approach are three major themes, all of which have a major impact on people's daily lives and socio-economic development in the region: AI for Health, AI for Business Innovation, and AI for Citizens. The starting point is an integrated people-oriented approach throughout the entire chain in the Amsterdam metropolitan region: 'Amsterdam as a living lab'.