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Closing the gap between humans and machines

AI IS NOT SCIENCE FICTION – IT'S SCIENCE FACT

Smart designs, huge ambitions

YOUNG RESEARCHERS RECEIVE VENI GRANTS FOR SMART IDEAS THAT WILL SHAPE THE FUTURE

Trying to break the downward spiral of obesity

WHY OBESE PEOPLE CHOOSE FAST FOOD RATHER THAN A HEALTHY MEAL

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Radboud University Radboudumc

It's everywhere: in your car, in your living room, probably even in your pocket. Artificial Intelligence (AI) is no longer science fiction; it's science fact.

Closing the gap between humans and machines

For years now, machines have been thinking for us in hospitals, on the internet, in the military and on our smartphones. They are capable of increasingly smarter and more complex thinking. Nevertheless, the most highly advanced robot is still unable to think like a human being. We may eventually get there, argues Marcel van Gerven, head of the Artificial Intelligence department at the Donders Institute: "I believe we're slowly but steadily closing the gap between natural and artificial intelligence."

Right now, that gap still exists, and it's quite large. The brain is extremely energy-efficient, while the smartest machines are big energy guzzlers. Computers still mostly carry out assignments, instead of acting on their own intent. They lack emotion and true creativity. Moreover, no matter how smart they are, even the most advanced forms of AI depend on data to acquire new skills. Van Gerven: "Consider self-driving cars. They work great on highways, but fail in a crowded city. That's because they have very little understanding of their surroundings and cannot cope well with unexpected situations. What's more, you have to train them on a huge amount of data, while people can learn from a single example."

UNDERSTANDING NATURAL INTELLIGENCE

In order to understand natural intelligence, we need to know what intelligence is and how it works. That's where neuroscience and AI become intertwined. "There's a virtuous cycle emerging between these two fields. Neuroscience offers new mechanistic insights while AI provides the theoretical foundations for understanding how learning, perception and action occur in humans."

Reconstructing the brain is certainly not the goal. “We want to understand the basic principles of intelligence and convert them into software. Then we will be able to create brain-inspired computational models that learn to perceive and act in complex environments. This is a key motivation behind our research.”

Synergy between neuroscience and AI is taking place at various levels. For example, recent work shows that the learning algorithm that is widely used to train AI systems can also explain learning in the human brain. Also, neuromorphic computing, which simulates the way human cells communicate, is offering more efficient solutions developing of smart systems.

Finally, by teaching robots or other artificial agents to predict their ‘sensations’, they can learn to solve complex control problems. This is particularly interesting, as many brain researchers regard the brain as a prediction machine, a theory that assumes that we perform actions based on a prediction. For example, stepping over a puddle of water to avoid getting our feet wet. Or turning our head because we expect to see what we’re looking for.

The work done by Pablo Lanillos, Assistant Professor in the AI department, is an example of how that theory is being translated into a robot (image). The robot wants to grab a moving cube, so it follows the cube closely and moves with its robot hand to reach it. “The model behind it lets robots close the gap between prediction and reality by taking action,” Van Gerven explains. “That robot wants to grab something, and it continuously corrects the gap between its predictions and resulting actions. This shows that we can make a robot behave the way people do, using techniques that are inspired by our insights into how the brain works.”

AI IN PRACTICE

Theoretical advances will have several practical implications. New developments in brain-inspired AI may lead to more robust, efficient and adaptive intelligent machines that can survive in complex environments. These machines can ultimately serve as the basis for super-smart care robots, a helping hand in a classroom, or a self-driving car that can manoeuvre safely in a city.

New intelligent algorithms also help brain researchers make sense of large amounts of data. Researchers at the Donders Institute study cognition and behaviour from the molecular level to the level of a human being. Large-scale machine learning will be essential for understanding the brain, ranging from analysis of genetic data to predicting neurological impairments in clinical neuroscience.

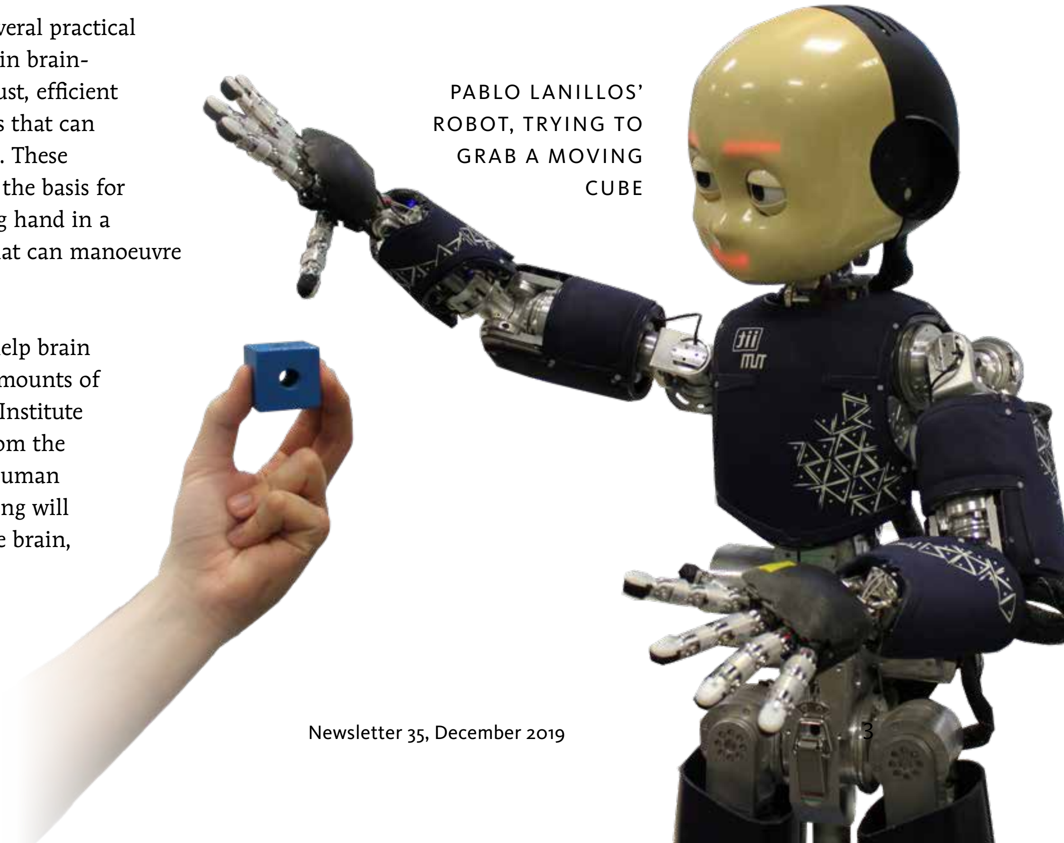
Innovation Centres for Artificial Intelligence (ICAI) are being founded all over the Netherlands, supported by industry. This year, Radboudumc and Radboud University founded the Radboud AI for Health ICAI lab. “Within this lab we aim to link fundamental AI research to clinical applications that can greatly improve healthcare. We’re starting projects ranging from AI-based diagnosis of genetic disorders to predictive modelling in intensive care. It would be extremely exciting if industry were to join forces with us to set up similar labs in other domains, such as smart systems, neurotechnology, education and sustainability.”

STATISTICS ON STEROIDS

The rise of smarter machines raises ethical questions. Is it safe to develop robots that are as smart as we are? What scope will they have for decision-making? While Van Gerven mainly focuses on developing new intelligent algorithms, he strongly advocates making trustworthy AI systems that respect human values. “This is particularly urgent since we are massively deploying AI systems that lack a moral compass.”

According to Van Gerven, much of today’s AI is in fact statistics on steroids. It will take many years before Alexa, Siri or Google Assistant provides a truly genuine, informed, intelligent opinion, instead of just carrying out commands. “We have ideas on how to get there, but some of the high expectations for AI might never be fully met. However, the road towards that end goal might be the most interesting aspect of the whole endeavour. It will lead to more capable general-purpose AI systems, better insight into our brains and new applications that will benefit society.”

Roeland Segeren



PABLO LANILLOS’ ROBOT, TRYING TO GRAB A MOVING CUBE

Smart designs, huge

Surya Gayet, Myrthe Faber and Jill Naaijen have received a Veni grant from the Dutch National Science Organisation (NWO) to conduct research in neuroscience. These talented researchers at the Donders Institute are eager to show the world that they are worthy of the €250,000 grant.

The many faces of mind wandering

Myrthe Faber uses her Veni grant to explore the world of mind wandering in order to shed light on several aspects of this abstract concept. Society perceives it as mainly negative: mind wanderers are not able to stick to a task. Nevertheless, many things about mind wandering are unclear. Where does it come from? How do we define it? And what is it for? Faber: "Day dreaming, for example, is often seen as synonymous with mind wandering, but it is in fact just a sub-category. And there may be positive aspects as well, which I hope to discover in my research."

An abstract concept is usually best explained with examples. When you're driving a car, mind wandering will have a negative effect on your attention to the road. But if you're reading a book late at night and the main character lives in Barcelona, mind wandering about a trip you made to that city might have a positive effect. Faber: "Mind wandering can make it easier to understand, remember and visualise the text. In this case, it can provide enrichment."
Faber will use several measurement methods. With eye tracking she can see to what extent readers focus on text. By using fMRI she aims to see which brain networks interact during mind wandering. A test must clarify if the participant remembered and understood the text better when mind wandering was triggered by the text. "I want to focus on mind wandering as a multidimensional construct. Combining the results of several measurement methods will hopefully help us to better understand this important part of our inner lives."

ambitions

Using brain insights to design safe self-driving cars

When we search for an object, our brain creates a mental picture of it, which helps us filter the enormous amount of visual information entering our eyes. One major challenge for our brain is that an object will look completely different depending on where it is located: an apple looks darker in the shade than in the sun, and smaller at 10 meters than at 2 meters. Researcher Surya Gayet wants to find out how our brain solves this problem.

The idea that we create a mental picture of the object we are searching for is well established in the literature. Most of this literature, however, is based on simplistic experiments where participants search for coloured lines on a grey background. Unlike visual search in the real world, participants in these simple experiments know exactly what they are looking for, regardless of its location. "In my experiments I will use photographs, allowing me to investigate how mechanisms of visual search operate in real life, where the appearance of the object we are searching for is unknown."

Using fMRI, he will test the hypothesis that our brain continuously adapts the mental picture of the object we are searching for. This would mean that our brain searches for a small apple in a distant tree and a large apple in a nearby tree. The computations underlying this key human faculty can be applied to computer-based visual search. Together with the Vehicle Safety Division of TNO, an independent research organisation, Gayet will implement human-like search strategies in self-driving cars. To detect pedestrians, the software will first predict the size of a pedestrian in the camera image, given its distance from the car. "This will allow the software to only process pixels that plausibly might contain a pedestrian and ignore all pixels that do not, thus saving tons of valuable computational resources and, hopefully, thus contribute to traffic safety."

Chasing the dream: finding a medicine for autism

Since the beginning of this millennium, there has been a general belief among scientists and medical experts that autism may be caused by an imbalance between two neurotransmitters: glutamate and gamma amino butyric acid (GABA). Nevertheless, this theory has never been tested. Jill Naaijen will be the first to do this, with a newly developed MRI-based method. She hopes that her research will lead to the development of drug treatment for autism.

A neurotransmitter is a chemical substance that allows different parts of the brain to communicate with one another. In earlier studies, indirect proof was found that an imbalance between glutamate and GABA is a sign of autism. These studies were mainly based on human post-mortems and animal models. Due to improvements in measurement methods using MRI, we can now see how the neurotransmitters may affect brain functioning in autism in living individuals. "It makes it possible to look at which parts of the brain are active when they are communicating with each other, while measuring fluctuations in GABA and glutamate."

The expectations are high. If Naaijen is indeed able to specify the effect of biological factors, it might even be possible to develop drugs for autism. Until now, there have been only a few experiments that involved giving people with autism non-specific drugs and this has met with only limited success. Scientists simply don't know enough about biological factors and autism is hugely complex: people across the spectrum differ in terms of symptoms and biology. With the new technique, it might be possible to see which parts of the spectrum need less or more GABA or glutamate to eliminate the symptoms. Naaijen: "It would greatly improve our knowledge of autism and this may even lead to new medicines. Hopefully my research will kickstart research into finding a drug to balance these two neurotransmitters."

Daan Appels

Go to our website to check out the latest news and events

Meanwhile at dondersinstitute.nl

SOME RECENT HEADLINES

- **New project to combat loneliness among the elderly using games**
More than half of those aged 75 plus occasionally feel lonely. With an ageing population this is a growing concern. A special collaboration between DELA, Radboudumc and Games for Health will investigate whether games that bring together elderly and young people can alleviate this social problem. For this purpose, they have received a grant worth around €500,000 from the NWO's research programme 'Complexity and Creative Industry'. Together, DELA and Games for Health will invest another €250,000 in this project.
- **Swarm of tiny drones explores unknown environments**
Researchers have built a swarm of tiny drones that can explore unknown environments completely unaided. This work is a significant step in the field of swarm robotics. The challenge comes from the fact that the tiny 33-gram drones need to navigate autonomously despite having extremely limited sensing and computational capabilities. Machine learning researchers from the Donders Institute helped tackle this challenge by drawing inspiration from the apparent simplicity of insect navigation.

SOME RECENT HIGH-IMPACT PUBLICATIONS

- **Visual areas of the brain can multitask: seeing the world while remembering images**
When we visualise clothing, a milk carton or our car keys, something similar happens in our brain as when we look in the wardrobe, fridge or a drawer and observe these objects directly. Rosanne Rademaker's research shows that imagining a simple visual image, such as a stripy line-pattern, activates the same part of the brain – the visual cortex – as seeing that object directly. What's more, both remembering and actually seeing objects can activate the cortex at the same time.
- **Exercising at home has a positive effect on Parkinson's patients**
In a large double-blind study, medical researchers investigated patients in the early clinical stages of Parkinson's disease exercising regularly at home for six months. This appears to have a positive effect on their motor disability that is comparable to the effects of conventional medication. The results were recently published in *The Lancet Neurology.*
- **Neuroimaging reveals hidden communication between brain layers during reading**
Language involves many different regions of the brain. In a neuroimaging study that was reported in PNAS, researchers show that there are hidden connections between brain layers when we're reading. The team used laminar fMRI to investigate what happens when people read Dutch words like 'zalm' (salmon) compared to pseudowords (e.g. 'rorf'), revealing for the first time top-down influences on deep brain layers.

PhD defences

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Trying to break the downward spiral of obesity

Cognitive neuroscientist Esther Aarts has received a five-year Starting Grant worth €1.5 million from the European Research Council (ERC). With this money she will investigate how chronic inflammation in people with obesity relates to their decision-making. The ERC described this linkage as novel.

“People who are obese are often asked why they can’t just motivate themselves to exercise more and eat healthier food,” Esther Aarts says. “But we all know that this is difficult. Only 1 in 50 obese people who lose weight will have the same weight a year later. This happens despite knowing the health implications of being overweight: they are more at risk of cardiovascular disease and diabetes as well as depression and dementia. Why is it so much harder for people who are overweight to adopt healthy habits?”

Esther Aarts will look specifically at inflammation. “The inflammation in your body affects the amount of dopamine you produce,” she explains. “Dopamine helps you to become more active. If you produce less dopamine, you’ll feel less motivated. This is a good thing, when, for example, you’re ill; your body needs rest to heal. We’ve all experienced this: when you have a fever, you don’t feel like doing much.”

“Studies also show that the fat around our organs is dangerous. This abdominal fat gets more easily inflamed and increases inflammatory levels throughout the body. What if it’s this inflammation and its effects on dopamine levels that are causing obese people to be less active? The less motivated you are, the less you exercise, and the easier it is to eat fast food rather than cook a healthy meal. It’s a downward spiral.”

She will try to determine the relationship between inflammation, effort and reward processes in the brain. To do this, she will put people in a brain scanner while they exert effort (by squeezing a handgrip) for various types of liquid-food reward. She will then test these relationships causally by putting people on anti-inflammatory drugs or drugs designed to increase their dopamine levels.

“Our brain is not disconnected from our body. If we can find biological factors that affect our brain and therefore our behaviour, we might be able to help people who struggle with their weight. And that will also dispel the stigma that they are themselves to blame.”

Vanessa Deij

THE MACHINE

44 metres of rat city

A walk from Ireland to Hawaii need not take long. In the brand-new maze at the animal lab in Nijmegen, it takes a matter of seconds. But the researchers are not interested in the exact duration. They want to know how the rodents learn the shortest route. “I want an animal to use its memory,” explains memory researcher Lisa Genzel. “We actually prefer a rat that hesitates, because it makes well-considered choices.” The labyrinth measures 9 by 6 metres and consists of four interconnected islands. To provide the test animals with clues, the islands are decorated with the colourful features of Hawaii, Japan, Easter Island and Ireland. With its 134 gangways and 56 intersections, the total course is 44 metres long. Genzel: “This is probably the largest lab-based rodent maze in the world.”

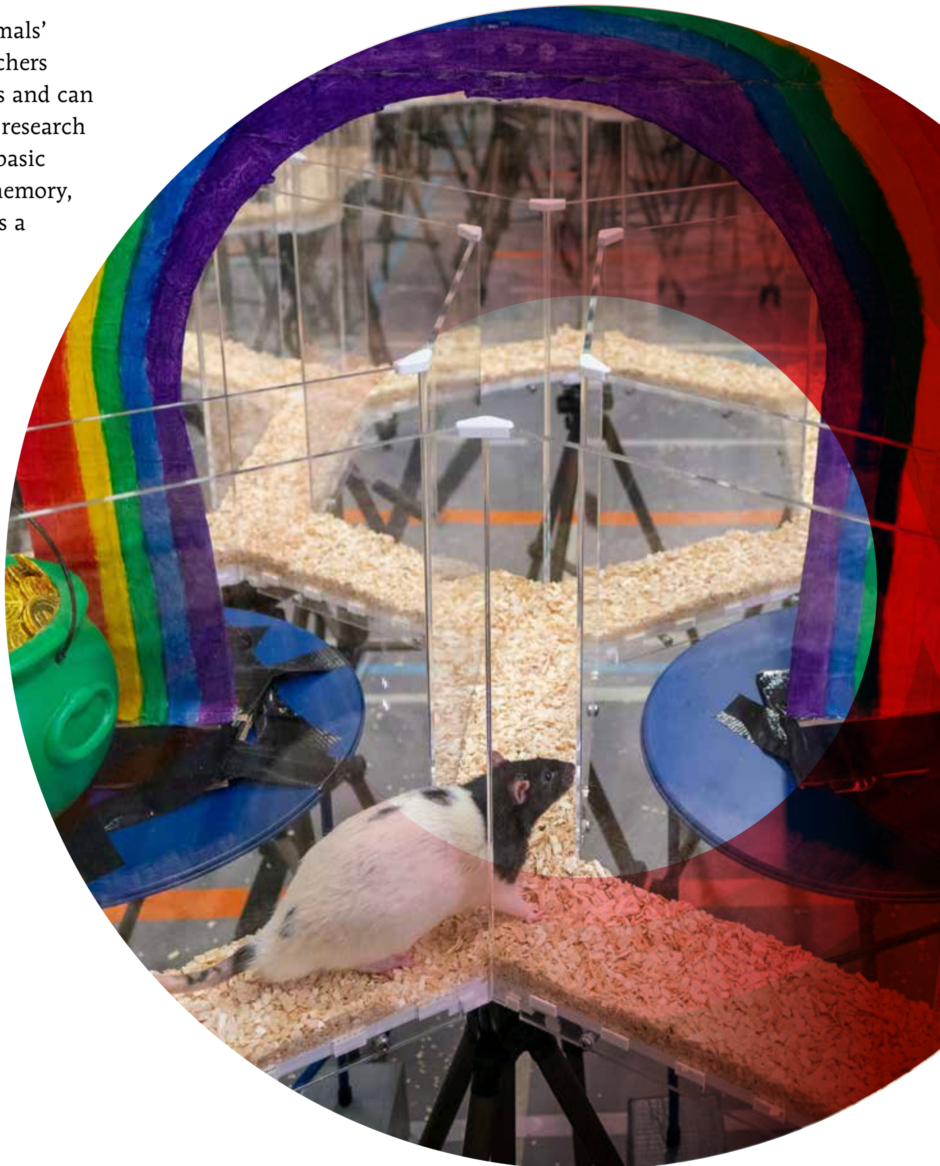
The maze is designed exclusively for rats. “It’s too big for mice. And you don’t want rats and mice in the same maze because they can smell each other. A rat is a predator for a mouse, so the scents would influence their behaviour.”

Twelve cameras in the ceiling follow the animals’ movements. By analysing their tracks, researchers learn about the semantic memory of animals and can obtain new leads that may also be useful for research in humans. Semantic memory contains our basic knowledge of facts. It differs from episodic memory, which consists of concrete memories, such as a meeting or a night out.

Genzel explains the difference with the example of orientating in a city. “If you live in a city for a while and you hear of a new restaurant, even the shortest description will help you to know and remember where it is. However, if you are new to a city, you’ll really have to look for the restaurant. We call this the schema effect or the previous knowledge effect: Once you know something, it’s easy to learn new related things.”

The maze is like a city for the rodents. “It takes about nine weeks for a rat to learn the map. We want to use this set-up to investigate how quickly they can take in new knowledge. To understand this, we analyse many trials. In most of them the animals don’t know their starting point, but they do know where the food is. Based on clues, they find the way to their goal.”

Roeland Segeren



DONDERS INSTITUTE Newsletter

The Donders Newsletter is published twice a year by the Donders Institute for Brain, Cognition and Behaviour, which brings together research groups at Radboud University and the Radboudumc as well as the Max Planck Institute for Psycholinguistics. Its purpose is to keep you informed of developments within the Donders Institute and the field of neuroscience.

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