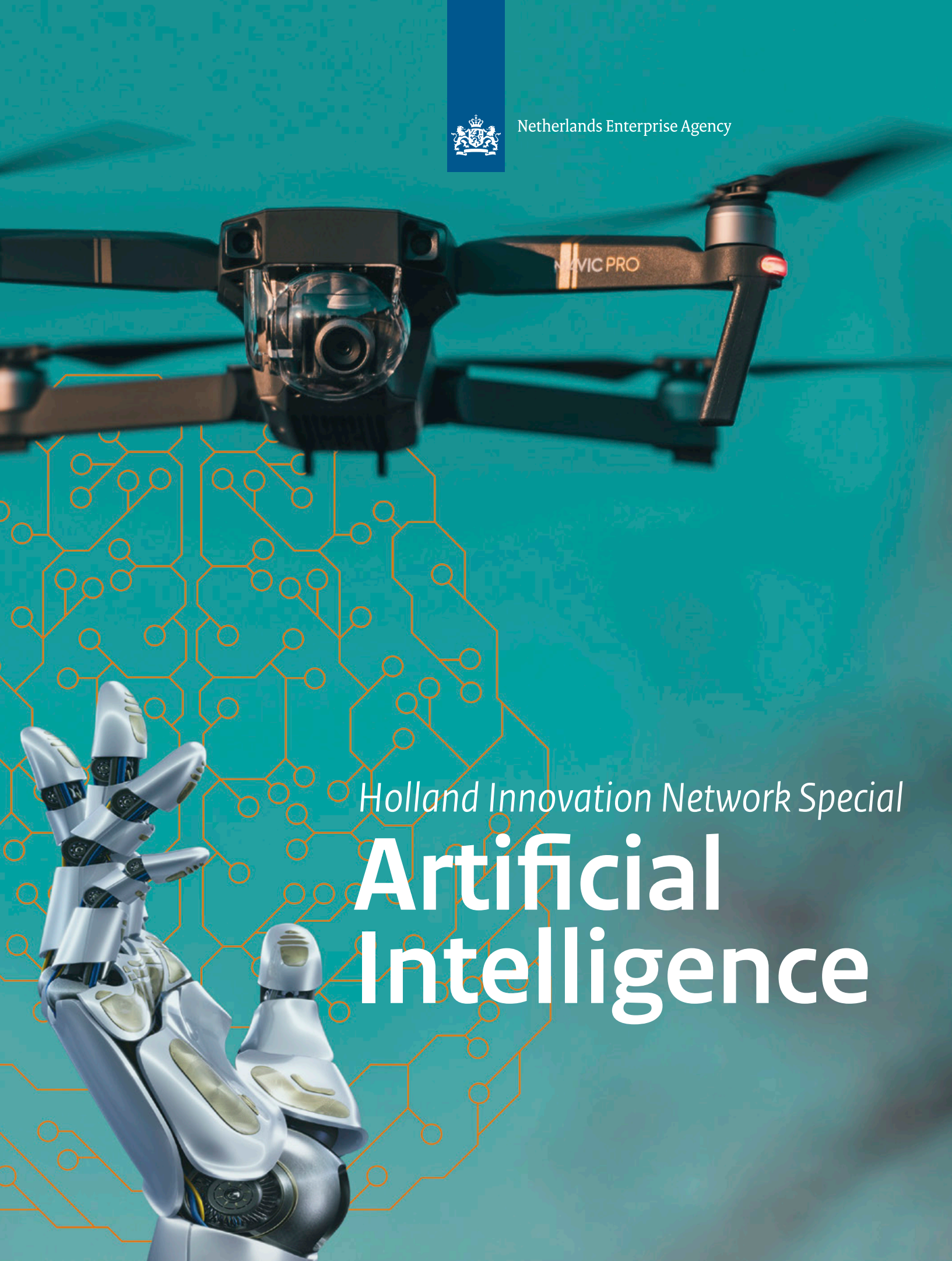
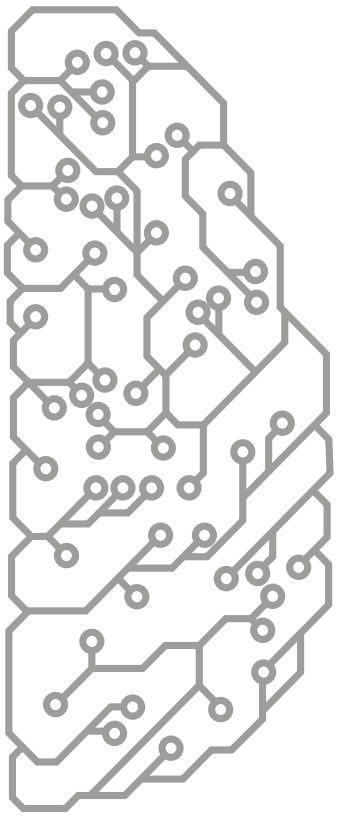
Netherlands Enterprise Agency



Holland Innovation Network Special

Artificial Intelligence

Table of contents



Dear reader,

Artificial intelligence is or will be a game-changer in many or all sectors of human life, just as the Industrial Revolution and the advent of ICT have been.

The ultimate scope of AI is as yet unknown but seems infinite.

With pleasure we present this special issue magazine of the Holland Innovation Network on the international trends and developments in the field of Artificial Intelligence in those countries where the Holland Innovation Network is based.
The Innovation Attachés give an overview of the scientific and technological developments, knowledge institutes and the government policy in their countries.

The Holland Innovation Network is there for you: companies, knowledge institutes en governments with ambitions in the field of international innovation and cooperation.
We have offices in the following countries: France, Germany (and Switzerland), Israel, Sweden, UK, Russia, USA (including Canada), Brazil, China, India, Japan, Taiwan, Singapore and South Korea. For direct contact see www.ianetwerk.nl.

You can call us in for networking or tailor-made service related to international science, technology and innovation cooperation. The Innovation Attachés have an important trendwatching role focused on science, technology and innovation developments.

We look forward to exploring how we can support your international ambitions. About Artificial Intelligence, but also about the other top sectors and key enabling technologies.

On behalf of the Holland Innovation Network,

Juri Roerink
Coordinator Holland Innovation Network

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Colophon

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The state of AI in the Netherlands

The size of the Netherlands belies its economic and innovation power: the 131st country in the world in terms of area is the world's 66th most populous country, the 18th largest economy of the world, and ranks 3rd in the Global Innovation Index. One area in which the Netherlands' innovation power bears fruit is artificial intelligence (AI). Some highlights from the sectors agriculture, healthcare, infrastructure, mobility and more.

Computer chip design and manufacturing is integral to AI

For over 250 years the fundamental drivers of economic growth have been technological innovations. The most important of these are what economists call general-purpose technologies, a category that includes the steam engine, electricity, and the internal combustion engine. Each one catalysed waves of complementary innovations and opportunities.

The internal combustion engine, for example, gave rise to cars, trucks, airplanes, chainsaws and lawnmowers, along with big-box retailers, shopping centres, cross-docking warehouses, new supply chains, and suburbs. Companies as diverse as Walmart, UPS and Uber found ways to leverage the technology to create profitable new business models.

The most important general-purpose technology of the 21st century is AI. In particular machine learning, i.e. a machine's ability to keep improving its performance using examples (or data) without humans having to explain exactly how to accomplish all the tasks it is given.

The advent of AI

Over the past few decades the calculating power of computers has increased exponentially, according to Moore's Law. Big data has arrived, as a result of a large part of our life playing out in the digital world. A third factor, enabled by the first two mentioned, is the rise of machine learning.

In machine learning, the computer 'learns' to distinguish connections and underlying relations in data, without having been explicitly programmed in advance. Machine learning operates through learning from data, building a model of reality and constantly refining it. On the basis of such a model, these algorithms are capable of producing data-driven predictions as outcomes.

Subsequently, they continuously build upon these outcomes, ever refining them. A very important concept within the field of machine learning is the concept of deep learning. This specific machine-learning technology uses so-called neural networks and a hierarchy of concepts. Complex concepts are defined in terms of simpler concepts. The software optimizes itself without humans necessarily being able to see how the algorithm adjusted itself. In other words, we only see input and output (i.e. the quality of a prediction); the algorithm used is a 'black box'.

The challenge with AI development, big data and machine learning is not only technological, but also lies in new organization and business models as well as using large volumes of data in a meaningful way.

Amsterdam: new world-class AI hub

In 2019, the University of Amsterdam (UvA) will start construction of a 'Premier League' AI hotspot at its Science Park. The planned 11,000 sqm building will accommodate Bachelor, Master and Ph.D. students in informatics, artificial intelligence and other fields of study, learning to conduct research as well as entrepreneurial skills. The city of Amsterdam has pledged € 4 million; the rest will be provided by participating (multinational) companies and acquired from other sources.

Maarten de Rijke, Professor of Informatics and coordinator for the new AI hub, told newspaper *Het Parool*: "With regard to AI, there is only one viable option: be active. If today you are at the top and do not follow through, tomorrow you will suddenly have fallen behind." AI studies have drawn 400-500 students over the past few years. And current research is already world-class, says De Rijke.

A good example of the AI created at the Science Park, is startup company Scyfer. Founded five years ago, it was picked up by US computer chip giant Qualcomm in the summer of 2017. Scyfer's AI will be integrated in Qualcomm's chipsets and wireless solutions. In order to foster similar startups the hotspot will create preconditions conducive to joint education, research and development in cooperation with the private sector.

Developing an AI institute goes beyond Amsterdam and its university, De Rijke states. "What we see, is that the societal debate on AI has been opened. Everyone supplies data to companies such as Google and Facebook. We have to set our own expertise next to it. The best way to have a degree of control is to develop technology that works and meets our own values."

Professor Max Welling, research chair in machine learning at UvA and co-founder of Scyfer, is also involved with the new hub. He

stresses the fact that the planned new AI hub is not meant to be an exclusively UvA or Amsterdam operation. "We are aiming for an open consortium of academic partners with a national scope and are in discussion with various industrial stakeholders." Welling explains that participating companies can be either multinationals, SMEs or startups. The idea is for a company to establish a research lab in the new building, thus investing in a laboratory infrastructure and co-financing research.

Dutch AI fields of excellence

Professor Welling considers the following subfields as sectors where the Netherlands has a role to play with regard to AI:

- High-tech: computer chip design and manufacturing, ASML, NXP;
- Agriculture: innovative AI and robotics in precision agriculture, greenhouse technology, food factories;
- Healthcare: excellent integrated and networked hospital structure, prevention using social media;
- Logistics, planning: reinforcement learning.

Welling sees Canada as a model country for the way it has set up and continues to invest in AI. He specifically means educating and retaining AI talent. "I hope and fully expect our government to recognize that the return on investment in AI is many times greater than the investment itself."
Until recently he would have mentioned the United States as the most important country with business opportunities for the Dutch AI sector. He now says the Netherlands should do better by also focusing on China, due to the size and growth rate of its AI sector.

Statistics Office in big data vanguard

In September 2016, the Dutch Central Bureau of Statistics (CBS) launched a unique initiative for big data research: the Center for Big Data Statistics (CBDS). Within CBDS national and international partners from government, business and science cooperate on big data technology and methods for producing official statistics.

Tjark Tjin-A-Tsoi, the director-general of CBS: "Big data has the potential of enriching, improving and speeding up the production of statistics, with less costs and administration. Many organizations are investing in big data technology. However, producing high-quality statistics on the basis of big data is complex. This concerns both quality and continuity. Our ultimate goal is producing better and more relevant statistics in support of government policy. Furthermore, automated integration of data sources and streams will lead to substantial improvements in efficiency."

International, private and university partners in CBDS include, the Netherlands' Central Bank (DNB), TNO Innovation for Life, the WorldBank, Microsoft, IBM, CapGemini, CGI, Dell-EMC, Maryland University and Michigan University.

Tjin-A-Tsoi: "We have quite a few challenges ahead of us with using AI for statistics. For example, government entities are obliged by law to provide CBS access to their data. With regard to big data of private companies it is as yet unclear if there is a legal obligation.

Another issue is the nature of big data. Much of it is high-frequency machine-generated data, for example from sensors. Integrating this data stream with our existing survey and administrative data requires new methodological solutions. 'Translating' big data into the statistics we would like to see is difficult in two respects. Firstly, what exactly do we measure when using traffic data or social media use? Your sample is not random anymore. The population you accidentally measure could be just a part of the population. Twitter users are not a representative cross-section of society.

When using big data, often you will have to combine different data sources in order to have an accurate picture. Big data is not always of the highest quality: sensors can break down, provide false readings – factors for which you have to adjust the results."

ASML is one of the leading tech companies actively involved in Dutch AI

VolkerRail employs CQM's AI solution for the timely detection of rail faults

Where are we now, after 18 months of CBDS? "The organization has been structured, people have been recruited, the finance has been taken care of, there is an impressive list of partnerships, data have been collected, priorities have been defined, and over the next few months new project results will be published frequently."

One example project concerns the energy transition, from predominantly fossil fuels to sustainable energy. CBS is charting energy consumption to present opportunities for decreasing it or making it sustainable. Optimal placement of charging stations for electric vehicles (EV) can be determined by measuring EV density, ensuring locations with maximum profit. Another aspect is the particulate matter situation, in relation to traffic streams intensity: how can we improve both?
The internet economy is another ongoing research project. What is the size of it, how much do the Dutch buy from foreign internet companies? This is a cooperation between CBS and Google.

Cities in the Netherlands are researching the smart city concept. CBS is assisting them with its urban data initiatives, providing methodological support with uniformly structured data.

AI in infrastructure: the case of VolkerRail

CQM (Consultants in Quantitative Methods), an Eindhoven-based company, applies data science and AI to business opportunities in high-tech, logistics, energy and agri & food. For railway infrastructure company VolkerRail they implemented AI to detect irregularities on the railway tracks. Huub van den Broek, lead consultant on this project: "A specially-equipped VolkerRail train produces video images of the Dutch railway system. The images are inspected for faults by trained inspectors. Small defects can grow into larger problem areas. Detection is imperative. Preventive maintenance ensures trains are using the tracks safely."

Together with VolkerRail, CQM developed and trained a so-called deep convolutional neural network to automatically detect such faults. Its network architecture is based on how the human brain processes visual information. After 'seeing' thousands of examples of intact and faulty rails, the network has 'learned' which characteristics determine classification of specific faults. When the neural network recognizes such a characteristic in new video images, the inspector is warned so the necessary actions can be implemented.

Van den Broek: "Of course, the greatest part of the railway tracks is not faulty at all. The neural network allows the inspector to focus on relevant images where suspicious spots are visible, increasing efficiency. A fine example of AI application."

Image recognition and visual inspection is a field where AI has developed at a giant pace. Self-learning systems now outperform humans. The private sector employs a large number of people for visual inspection, whereas this task can efficiently be 'outsourced' with AI.

Another growth sector within AI is analyzing and interpreting written or spoken texts. Google Translate has been substantially improved by using AI. This smart program has developed its own intermediate language by which any language can be translated into any other. At CQM, smart text analysis is used to support marketing departments in analyzing large volumes of reviews and ratings. What are their clients talking about, what is the general sentiment, what settings do they have to adjust to improve their products and services?

Van den Broek sees the greatest opportunities for 'Dutch AI' "in fields where the Netherlands is traditionally strong, such as agri & food, banking, energy, high-tech and logistics. AI systems for decision-making support can take these sectors to the next level." He identifies major tech companies as more important than countries for determining where Dutch AI businesses should focus. In addition to well-known US players, these are Alibaba, Baidu and Tencent. Van den Broek sees the big (user) data these companies have collected as their most valuable asset for success.

AI education, training and life-long learning is the most formidable challenge for the coming years, according to Van den Broek. In conclusion, he believes the positive outcomes far outweigh the negative aspects of AI. "Let us not get stuck in negativism, stimulate entrepreneurship in a major way and let AI bring our welfare and well-being to uncharted levels."

Ethics, norms and values: the Dutch approach

Former lawyer Bendert Zevenbergen is a research fellow on the ethics and politics of AI at Princeton University. Working at the Center for Information Technology Policy and

the Center for Human Values, he views AI through the prism of norms and values.

"I believe the Netherlands has a special role to play in terms of the ethical dimension of AI. We have always been a country that is relatively strong in societal and ethical reflection on technological issues. What we should do is acquire the knowledge from various AI sectors and test it in AI applications, subsequently feeding the world our ethical and societal conclusions."

In Zevenbergen's analysis, both China and the US are not the kind of society the Netherlands can be or wants to be. Therefore, building a cooperation network with the countries around us seems logical: France, Germany and the United Kingdom. "The French government has recognized that vast amounts of money have to be invested in order to advance French AI. The same goes for Germany, where the automotive sector has also produced a standard textbook in the first manual for autonomous cars, which is now used internationally.

Developments in connected mobility

Maarten Steinbuch is Professor in Control Systems Technology at the Eindhoven University of Technology. One of his projects is smart mobility: vehicles connected to the mobility infrastructure and to each other through internet. The connected vehicle is so much more than just an autonomous / self-driving car. Steinbuch means vehicles and infrastructure communicating in real time, for example with cars platooning on the road.

"The classic concept of mobility has come under pressure, because of climate change and the transition from fossil fuels to sustainable energy. Traffic congestion in metropolitan areas is a global problem. If we can find ways to apply technology for making cars smarter and more autonomous, the drivers can perform tasks other than actually driving. In other words, we can make better use of our valuable time."

Steinbuch sees many more applications for smart mobility such as car-sharing, reclining bicycles, NS hire bikes – all as part of one smart mobility concept. Computer chips producer NXP already provides most of automotive electronics for all major car brands, thereby having a unique position in the world.
Robotics also comes into play. His group has won the world soccer championship for robots three times. "You may ask yourself what does this have to do with smart mobility? Well, our soccer robots use the same algorithms which can be used for smart cars. The robots have spatial awareness and learn from what is happening on the ground, as an autonomous car will do when driving on the road. Is that a lamp post or a slender student crossing the road for which it has to stop?"

The Netherlands is the first country in the world where public roads have been used to test connected mobility. Steinbuch's university has cooperated with TNO and DAF Trucks to practice twin driving with trucks.

"Most automotive companies' R&D focuses on self-driving cars, not on connected driving. Our leading position is an excellent opportunity to build upon", he concludes.

AI in agriculture

Erik Pekkeriet is senior business development manager Agro Food Robotics at Wageningen University & Research. What can he tell us about the AI strengths of the Netherlands in agri & food? "There are too many fields to mention where AI has been successfully applied. For example in feature extraction, classifying food quality, pest and disease recognition as well as harvest and crop handling using vision technology (either in 2D/Slam or 3D (TOF, Stereo, structured light, VI). Actual challenges now are time-restricted learning, to monitor and control crop progress (season, cultivar, lighting, grower-specific crop handling and greenhouse or field distribution) with the broad variety on plant sensors, as well as human robot collaboration. Wageningen University & Research is involved in all of these technologies." Priority countries for the Dutch AI sector in his field are Australia, Japan and the US.

Preparing the Future of Society

The recent surge in investments and strategic focus on Artificial Intelligence (AI) is based on serendipity: many favorable conditions coming together at the same time. This article on developments in the United States in general is complemented by separate articles on AI developments in Boston and Silicon Valley.

By Sigrid Johanisse, *Holland Innovation Network, Washington, D.C.*

Chips have become faster, cheaper and highly capable of processing vast amounts of data; the exponential growth of data via larger platforms; the rise of tech talent which is able to develop algorithms; low costs of data storage; availability of capital; and the advent of new areas for commercial application. From autonomous driving to agriculture and cyber security, from defense to fintech or healthcare: AI can be the game changer and everybody wants to be first.

In view of these conditions and areas for application, it is not surprising to see that AI and machine learning have become the next investment boom of the tech industry in the United States (US).

Over the last five years, companies such as Apple, IBM, Microsoft, Google, Facebook, Intel, Amazon, Salesforce, Uber et cetera have invested billions in AI research (90%) and acquisitions (10%). US-based companies have absorbed 66% of total worldwide AI investments in 2016, with China following in second place. [*McKinsey's State of Machine Learning and AI, 2017*].

According to CB Insights, the majority of all venture capital-funded AI startup companies are still in the US, with most of them located in San Francisco and Silicon Valley. New York and Boston come in third and fourth. The average starting salary of a computer science graduate who can develop algorithms is between USD 150,000-200,000.

Support by US government

It is not just the private sector which is embracing AI. The US government is also supportive. In order to ensure global leadership in AI by the US, the White House has chartered a Select Committee on AI under the National Science and Technology Council. It includes the National Science Foundation (NSF), the Office for Science and Technology and DARPA. The NSF and DARPA have put forward machine learning and robotics as one of the main strategic research areas. In September 2017, the White

AI hub New York

New York is the third AI hub in the US. With challenging AI startups such as X.AI, Clairifai, AlphaVertex, Behold.AI, CambrianIntelligence and Klustera the city sets the pace and influences business models in fintech, healthcare, robotics and consumer services. These companies specialize in image and voice recognition, but also perform highly specialized tasks in manufacturing. Facebook's AI department is anchored in NYC, as well as IBM's global Watson headquarters. Columbia University has a data science institute and the Technion-Cornell Institute is the bridge between New York and Tel Aviv. In October 2017, Dutch startup incubator B. NYC was established to provide AI-focused startups from the Netherlands with a (speedy and) soft landing in the US.

House published its vision on the future of technology in the US, stressing the importance of Machine Learning and autonomous technologies for transport and other areas which would put America First.

To prepare the workforce for the jobs of the future, the Trump administration will invest strongly in STEM education and workforce training programmes. In addition, the US Congress has adopted federal legislation to facilitate autonomous test driving throughout the US. This has attracted investments from Volkswagen, BMW and Mercedes to the US in order to keep up with the latest technological developments.

Societal debate in the US

At the same time, is not only commerce, science and government who are paving the way towards the future. AI and machine learning have sparked a broad societal debate regarding their impact on our future. Will robots eventually 'compete' with humans or take our place and jobs? Do we need to develop a conditional framework in which AI is only there to assist people and improve the quality of life? What are the legal and etthical aspects of AI?

There is widespread concern in the US Congress that AI 'is taking away jobs'. Several organizations are questioning the ethics - or better the lack of ethics - and the tech-driven focus of AI, which ignores the impact and the diverse reality in which we live.

Under Obama's administration [*Artificial Intelligence, Automation and the Economy, 2016*] a multistep approach was being developed to deal with these societal policy-related issues. These efforts are now being continued at the Center for Information Technology Policy (CITP) in Princeton, under the guidance of Ed Felten. Via the Princeton Dialogues of AI and Ethics, the CITP publishes case studies combining various scientific disciplines such as ethics, law, computer science and policy-making.

Industry has also joined forces by funding the not-for-profit OpenAI Institute. In it, large tech platforms openly share knowledge and debate the impact of AI. Stanford University is writing history by studying the effects of AI on our life and work for the next 100 years (*AI.100*). Stanford professor FeiFei Li and Melinda Gates have started an organization AI4ALL to eliminate bias from algorithms. The AINow Institute in New York brings together several disciplines to understand the social implications of AI.

AI fight club

In the US, the best and brightest minds are routinely challenged through competitions to develop novel technologies which are potential game changers in different fields of research and applications. Especially regarding the potential impact of AI and the future of cyber security and cyber warfare. Many such challenges are being organized by both government and industry like DARPA and Google to explore new areas of research in AI related to cyber security. Recently, a five-month contest started, run by Kaggle (Google), where offensive and defensive AI algorithms are doing battle to gain insight how to harden machine-learning systems against future attacks and study their limits. The results will be presented at a major AI conference later this year in the US.

The AAAI (Association for Advancement of AI, founded in 1979) studies all developments and shares all available knowledge. In this way, the US is not only the commercial testbed of innovative AI-driven solutions but also the societal testbed. See the debate between Elon Musk (Tesla) and Mark Zuckerberg (Facebook) on the question whether AI would be a fundamental risk to human civilization, and where Musk called for pro-active regulation.

Developments in Canada

Just across the border in Canada, the Trudeau government has published a Pan-Canadian Strategy on AI based on attracting talent and investments across the globe, with the Canadian Institute for Advanced Research (CIFAR) in Montreal and the Vector Institute in Toronto at its core. Canada is convinced the fastest way forward is having top talent in your institute, which automatically attracts more talent, because 'smart people want to work with other smart people' and consequently draw large investments from US tech companies such as Facebook and Uber. The strategy requires companies not only to invest, but also to open up an R&D lab in Canada where staff can both work for universities as well as industry. It is the elements of knowledge exchange and interdisciplinary thinking which make all the difference. This concept opens up a lot of creativity and fosters cross-overs. The Canadian government has invested CAN $ 125 million (USD 97 million). The private sector contribution equals this amount.

AI in US agriculture

By Karin Louzada - The application of AI in agriculture promises automatic predictive solutions for making real-time decisions in the field. Producing high-quality food while at the same time reducing the use of land, water and labor resources, with 24-hour uninterrupted production. However, its implementation comes with significant challenges. Agriculture is notoriously complex: an open system with continuously changing variables, unpredictable environmental conditions, diseases and pests, and few measurement points (e.g. yield measurements once a year). It is difficult to statistically quantify the results of intervention and solutions are hard to test, validate and implement.

Nevertheless, clear opportunities for AI and machine learning have been identified in, for example, accelerating the breeding process. Seed companies are already using AI to combine phenotype data (acquired through multispectral imaging) with genetic and environmental data to determine which crop breeds and conditions will produce the highest yields. Exciting applications are crop imaging, pest imaging and identification, sensor-based intelligent irrigation, vertical farming and autonomous tractors and drones.

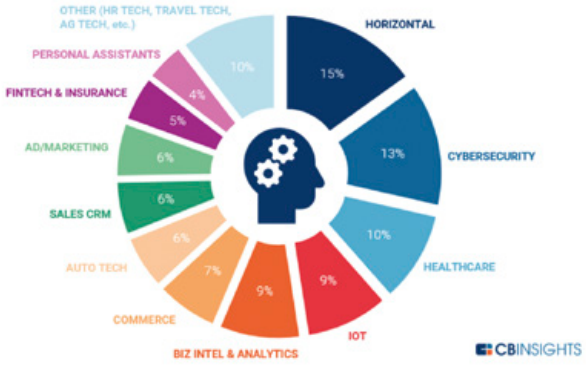
Automated crop management solutions for thinning, weeding and picking are of particular interest in California for replacing back-breaking work in a sector already suffering from a rapidly dwindling labor supply. A prime example is the LettuceBot by Blue River Technology, a Silicon Valley-based company developing a suite of AI technologies for agriculture. Recent conversations with growers and specialists in the field have taught us that most growers are slow to take up new technologies on their own. However, large agribusiness firms are showing great interest, as testified by the recent purchase of Blue River by John Deere for USD 305 million!

ANNUAL CVC FUNDING PARTICIPATION TRENDS TO AI COMPANIES

2012 – 2017 (H1'17)

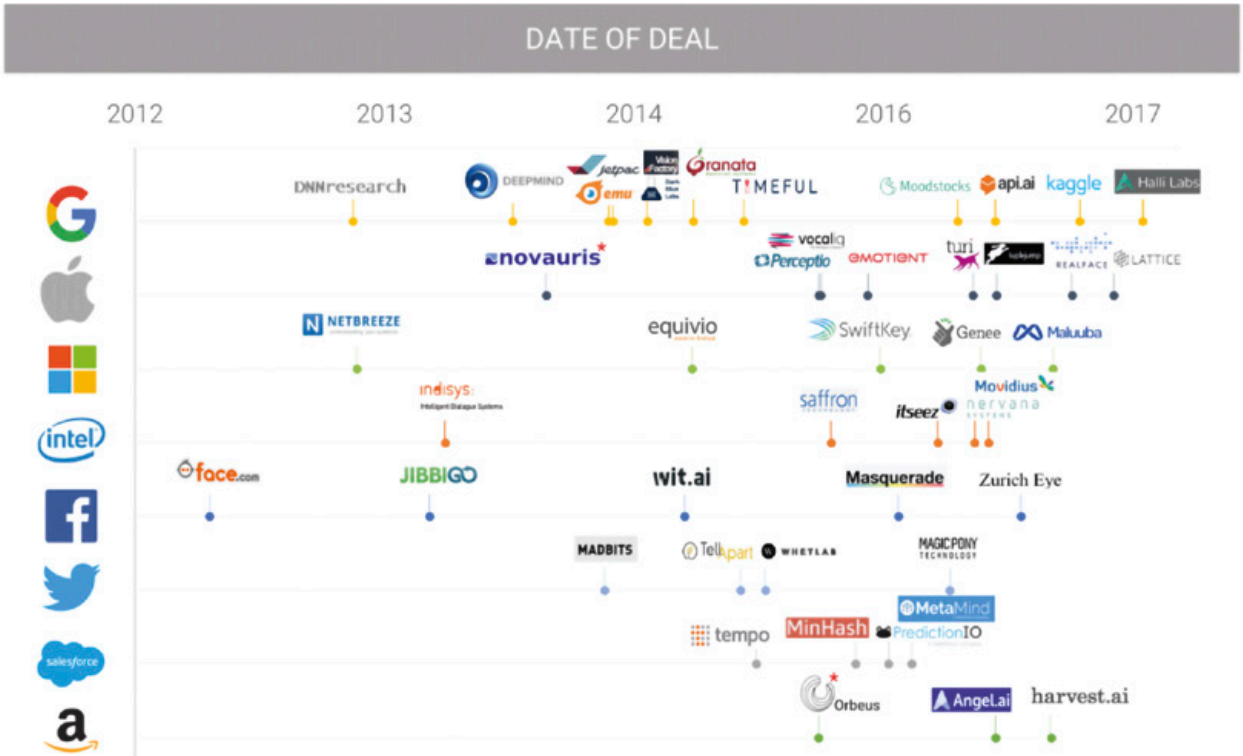
CVC DEAL SHARE INTO ARTIFICIAL INTELLIGENCE SUB-SECTORS

2012 – 2017 (H1'17)



RACE FOR AI: TOP ACQUIRERS OF AI STARTUPS

2012-2017 YTD (as of 7/21/17)



Boston

Because of its many top-ranked universities and research institutes, active startup scene, venture capital availability and the presence of mayor players such as IBM, Google, Boston Dynamics and GE, Boston is well-equipped to be a strategic hub for the new wave of Artificial Intelligence (AI).

The eight internationally ranked universities of the Greater Boston area

University	*Computer Science program*	*AI program / research*
Massachusetts Institute of Technology	X	X
Harvard University	X	X
Boston University	X	X
Tufts University	X	X
Boston College	X	
Northeastern University	X	X
Brandeis University	X	
University of Massachusetts – Boston	X	X

By Walter de Wit, Christian Cohen, Tyrone Pater,
Holland Innovation Network, Boston

Boston is home to both Harvard University and the Massachusetts Institute of Technology (MIT). In addition, the Boston region has six other internationally ranked universities.

The Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) is the engineering school which offers degrees in those fields. AI is part of its Computer Science curriculum. Courses on the theme are widely covered, ranging from Machine/Deep/Reinforcement Learning, Visual Recognition, Language and Logic, and Super Intelligent Machines.

The Harvard Innovation Lab (i-Lab) is a resource for Harvard students interested in entrepreneurship. Several AI startups have originated from the i-Lab: Intelligence Associate, Heartstring, Evisort and Finfox.

The Electrical Engineering and Computer Science Department (EECS) at MIT has a solid reputation for making a global technological impact in the world. The Computer Science department offers master's and doctoral programs with courses in areas such as algorithms, information theory, multicore programming and robotics. The Boston Globe reported that MIT's Introduction to Machine Learning has become one of the most popular classes on campus, with 700 students signing up this year.

The largest research laboratory at MIT is the Computer Science and Artificial Intelligence Laboratory (CSAIL). CSAIL's research groups are organized into three focus areas: artificial intelligence, systems and theory. In addition, the MIT Media Lab is participating in a USD 27 million initiative on AI ethics and governance, in collaboration with the Berkman Klein Center for Internet and Society at Harvard University.

In October 2016, MIT announced the creation of The Engine, a new venture for entrepreneurs working on technological innovation with the potential of changing the future. The Engine prioritizes breakthrough ideas over early returns by providing capital to tough tech startups. On September 19th, 2017 The Engine announced it had raised USD 200 million to invest in startups. The AI startup iSee is one of the first companies in their portfolio.

Healthcare

The combination of data and AI has the potential to improve outcomes and reduce costs within healthcare, by applying machine learning algorithms and predictive analytics to reduce drug discovery times, provide virtual assistance to patients, and diagnose ailments by processing medical images, among other things. In Boston both IBM and General Electric (GE) aim to become a leader in AI and healthcare.

As mentioned, IBM recently announced that it partnered with MIT to create a USD 240 million AI lab, with healthcare as one of the focus areas. Moreover, IBM spent over USD 4 billion in the past two years in acquiring healthcare-computing companies and expanding its AI capabilities. IBM acquired AI-healthcare

MIT-IBM Watson AI Lab

In September 2017, IBM and MIT announced that IBM is investing USD 240 million to create an AI lab in partnership with MIT. The new lab will be mobilizing over 100 AI scientists, professors and students to carry out joint research at the IBM's research lab in Cambridge. Researchers at the lab will pursue research in fundamental AI which include the research areas of AI algorithms, AI hardware and software. It also aims to increase the impact of AI on industries such as healthcare and cyber security.

The MIT-IBM AI lab is a new addition to a multi-year collaboration between MIT and IBM. In 2016 IBM announced a long-term collaboration with MIT's Department of Brain and Cognitive Sciences to make progress in the field of machine vision. Moreover, IBM invested USD 50 million in a five-year research collaboration on AI and genomics with the Broad Institute of MIT and Harvard.

GE and Partners Healthcare

GE and Partners Healthcare launched an initiative to employ artificial intelligence to improve medical care. The ten years long effort will include clinical and technology experts at the Partners-owned Massachusetts General and Brigham and Women's hospitals working alongside engineers and developers at GE. The partnership is initially focused on developing deep learning algorithms that analyze medical images to help identify patients that need follow-up or intervention by doctors. But over time, they also want to create applications for genomics, population health, and other areas of medicine. Executives from GE, one of the nation's largest corporations, and Partners, Massachusetts' largest not-for-profit hospital network, said such technology has the potential to help care providers do their jobs more efficiently so that patients receive more accurate diagnoses and better treatments. Without disclosing specifics, both companies said they will spend a significant amount on the initiative. And both stand to gain revenue if they are successful in creating useful software programs that can be sold to hospitals around the globe.

companies Ann Harbor, Merge Healthcare, Phytel and Explores in the last two years. IBM claims that Watson software is used in a dozen of the largest life sciences companies and that more than 55 hospitals and healthcare organizations implemented its oncology tools. Watson says that it can quickly sift through sets of data to perform drug research and to make diagnoses. Watson software analyzed 1,000 cancer patient cases and suggested potential treatments that doctors were not able to identify in about 30% of the cases.

Many of the Boston region-based AI startups have a focus on healthcare. Already mentioned is the Cambridge-based startup PathAI. Another startup located in Cambridge is OM1; they use machine learning algorithms and the vast amount of healthcare data to create better standards for procedures and treatments. Welltok is an AI startup located at Burlington, MA, and is one of the five most well-funded AI companies in healthcare (CB Insight). Its mission is empowering consumers to achieve and sustain their optimal health. Their CaféWell Health Optimization Platform connects consumers with available and relevant resources, benefits and rewards using a data-driven, personalized approach. Some other AI startups in Healthcare in the Boston region are Jibo, Legionarius, Neurosleeve, and Bergh Health.

Boston hospitals are also looking to improve hospital care by integrating AI in their organizations. The Beth Israel Medical Deaconess Medical Center (BIDMC), one of Harvard's teaching hospitals, is currently working on an intelligent sepsis monitoring system to continuously identify and risk-stratify patients at increased risk of sepsis. Massachusetts General Hospital is partnering with Nvidia to use its new deep learning supercomputer and improve the detection, diagnosis, treatment and management of diseases.

Robotics

Another very lively AI domain in Boston is robotics. The various universities in the Boston region ensure that a significant amount of talent is available to deal with the hard problems that are often associated with robotics. Additionally, the sheer number of universities in the region results in a large number of startups focused specifically on robotics.

Boston is well-positioned to lead the next revolution in artificial intelligence

The Boston startup scene

Boston has a rich ecosystem of AI startups, focusing on a wide range of applications of AI, some examples are Interactions, Indigo and PathAI.

Interactions provides virtual assistant software that combines speech recognition and human intelligence. It is the best-funded AI startup in Boston with USD 167 million funding raised. Indigo, which raised USD 150 million, helps farmers to make sturdier crops by applying machine learning algorithms to a large database of plant genomes. The Cambridge-based PathAI developed a platform that provides automated and data-driven pathology analysis.

In 2016 venture capitalists in the US invested in 658 AI-related startups, with a total invested amount of USD 5 billion. An increase of 61% compared to 2015. The growing interest of venture capital firms in AI is reflected in Boston. Boston-based venture capital firm Glasswing emerged to exclusively invest in AI-related firms. In June 2016, it announced that it aimed to raise USD 150 million to invest in AI startups. Other AI investors based in the Boston area are Hyperplane investors, Procyon Ventures and GE Ventures.

The MIT Duckietown course is a class on advanced autonomy at MIT. It is a hands-on, project-focused course and involves self-driving vehicles and high-level autonomy. Students are asked to design an autonomous robo-taxi system for the city of Duckietown. Although they work on scale, the problems students encounter are comparable to the problems of Tesla and Uber. All materials, such as hardware design, software, and teaching materials, are released as open source.

Boston AI events

AI World Conference & Expo, December 3- 5, 2018
The industry's largest independent event focused on enterprise AI and machine learning. Designed to help business and technology executives cut through the hype,and learn how advanced intelligent technologies are being successfully deployed.

Boston AI Meetup – monthly events
The Boston AI Meetup consists of almost 2000 members and have monthly meetups about the most exciting and inspirational AI innovations in the Boston region.

Furthermore, the prestigious Worcester Polytechnic Institute (WPI) is making strides when it comes to robotics. With the first-of-its-kind bachelor's degree in robotics engineering and one of the first such graduate programs in the nation, WPI is at the forefront of robotics education and research.

In total, there are almost 40 research labs in the Boston region that have a focus on robotics. Some other notable examples are MIT CSAIL, Harvard Wyss Institute, Harvard Biodesign lab, the Robotics and Intelligent Vehicles Research Laboratory at Northeastern University and the New England Robotics Validation and Experimentation Center at the University of Massachusetts.

In addition to the various research labs, there are other initiatives that help to improve the robotics ecosystem in Boston. Located at the Seaport area, MassRobotics is the collective work of a group of Boston-area engineers, rocket scientists and entrepreneurs, who created an innovation hub and startup cluster focused on the needs of the robotics community. MassRobotics' mission is to help create and scale the next generation of robotics companies. They prove entrepreneurs and startups workspace and resources they need to develop, prototype, test, and commercialize their products and solutions. Another program is Autodesk BUILD, their program supports research and startup teams as they build and test projects and prototypes. Residents can access training, expertise, areas for large-project work and more than 60 pieces of advanced fabrication machinery.

Boston is home to several leading robotics companies. Originally a spin-off of MIT, Boston Dynamics builds advanced robots highly skilled at mobility, agility, dexterity and speed. Their robots use sensor-based controls and computation, which allows capabilities of complex mechanisms. iRobot is a leading global consumer robot company, which designs and builds robots that empower people to do more both inside and outside of the home. They seek to build an ecosystem of robots and data to enable the smart home, both through internal initiatives and by building strategic external partnerships. Finally, Rethink Robotics is known for their collaborative robots Sawyer and Baxter. In addition, there are dozens of robotics startups in the Boston region, ranging from warehouse and agricultural automation to exoskeletons and social robots.

Overall, Boston seems ready to become one of the leading AI hubs

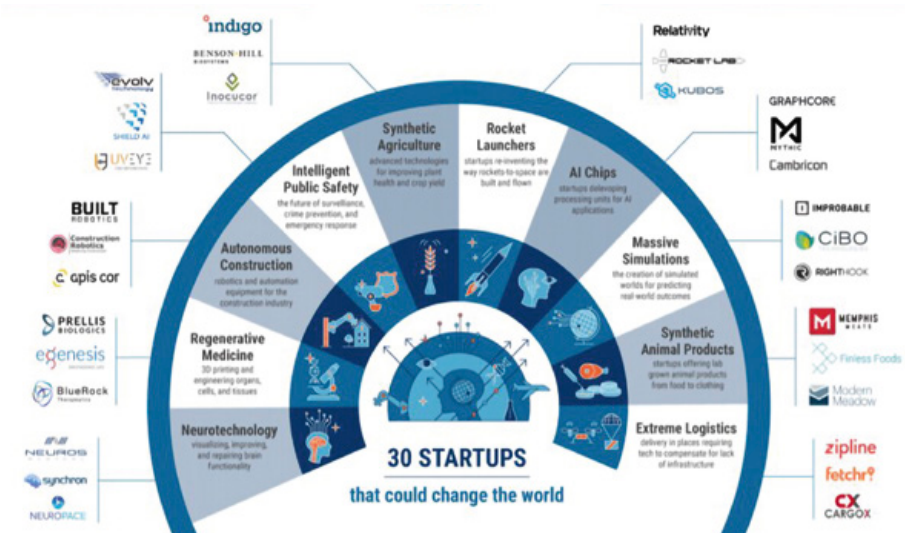
Overall, Boston seems to be ready to become one of the leading AI hubs. Boston region's unique position in enabling new technologies with its leadership in academic and medical research resulted in a robust and growing AI ecosystem. Combining this with a very active startup scene and industry heavyweights such as Amazon, IBM Watson and General Electric (re)locating to the state, Boston is well-positioned to lead the next revolution in Artificial Intelligence.

Silicon Valley

In 2017, the US was the second largest investor in AI companies with 38% of total worldwide AI investment. The US has now been surpassed by China with 48%. In the number of AI companies the US is still in the lead. Based on keyword searches by CB insights, China is also taking over the majority of AI patent applications.

By Wouter Roelofs, *Holland Innovation Network, San Francisco*

In Silicon Valley AI is a top priority, with Google in the lead. Since 2012 it has acquired the largest number of AI startups, followed by Apple, Facebook and Amazon. At the annual Google I/o conference in March 2018, they showed their most advanced conversational AI (chatbot) interacting with humans and understanding more context than ever before.

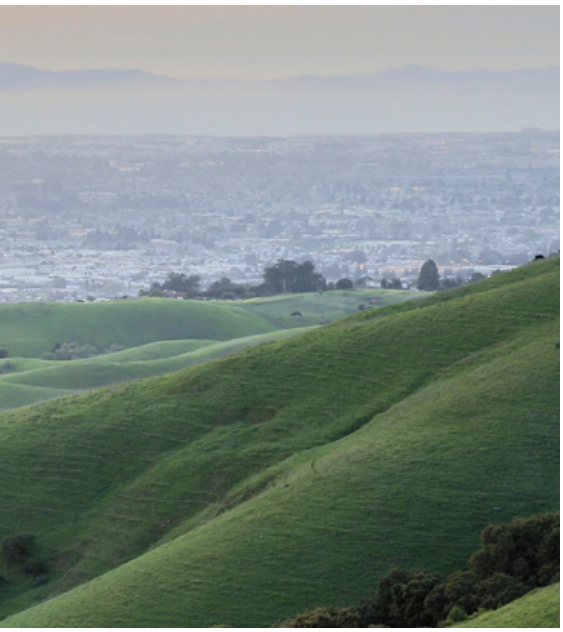


Most investments, advancements and applications are now made in the Healthcare, Cybersecurity and Enterprise AI areas. The big shift in last year's developments was from AI in the cloud capabilities to AI to the 'edge', meaning to devices that we use every day, such as our smartphones (iPhone X with facial recognition) and other devices executing more complex tasks.

Questions most often heard are: how can AI enhance our products to the next level? But also: is AI the blessing in the tech world we were all waiting for or are we 'summoning the demon'? Or will it 'only' eliminate our jobs?

AI is already benefiting platforms and businesses such as Uber, Netflix and many others. AI is transforming everyday products to be more convenient for users and will likely transform society as a whole. Companies such as IBM, Intel and Salesforce have business solutions to integrate AI technologies in existing work processes and making businesses more efficient and effective.

Amazon has highly automated warehouses with robots (100.000+) but the more refined



and delicate tasks are still performed by humans. AI replaces dull, dangerous and dirty jobs but a whole realm of new jobs will also emerge.

Furthermore, a debate has started on the development of logarithmical biases, as most developers are young males, white and Asian. Initiatives as AI4ALL from Stanford University pledge for more diversity in tech and to involve a wider diverse group in the development and the capabilities of AI.

Trends and investments

Since 2012, venture capital firms have engaged in escalating levels of investment activity to AI start-ups. The trend reached an all-time high in 2017: in the first six months alone venture capital participated in USD 1.8 billion worth of disclosed equity funding across 88 deals to private AI companies, already exceeding 2016's funding total.

Silicon Valley makes up for 40% of investments in AI globally. This may not come as a surprise, with the Bay Area housing the headquarters of some of the world's largest tech companies such as Google, IBM and Apple. Since 2012, Google has acquired twelve AI startups, making it the most active acquirer. Over the past five years, investments in AI have increased significantly. In 2016, McKinsey estimated global investments in AI to be between USD 20 and 30 billion, an increase of 300% since 2013.

Large companies in the western United States are even setting up AI-focused venture capital funds to solely focus on AI, such as Google's Gradient Venture, Microsoft Ventures and Salesforce Ventures. This indicates the importance of AI to US companies.

When looking at the fifty largest startups in AI, it is clear that Business Intelligence and Analytics and Core AI are dominating the invested industries in the United States. However, in the rest of the world, Healthcare received the most investments. Companies are not only investing in startups but also in patents. CB Insights analyzed five of the largest tech companies: Google, Microsoft, Amazon, Apple and Facebook. Seattle-based company Microsoft leads the group with more than 200 AI-related patent applications, followed by Google, Amazon, Facebook and lastly Apple. Even though American companies only really started investing in AI in 2012, it is evident that AI will continue to grow exponentially in the near future.

Research, innovation and talent

In Silicon Valley, there is a shortage of talent; with thousands of unfulfilled open applications at all major companies. Also, for AI a whole new workforce is needed. Some of the new professionals are educated and trained at the Californian universities, but talent is scouted worldwide.
All major universities in California have research groups on AI and experiment with application of research. The universities and corporates work together on a wide variety of projects. Nowadays, main research goes into extracting quality data with vision analytics and analysing existing data. With Machine Learning the focus is on getting computers to learn quicker with less data input.

Two examples of major universities in California are Stanford and UC Berkeley: Stanford University hosts the 'One Hundred Year Study on Artificial Intelligence (AI100)' and invites leading thinkers from several

In Silicon Valley there is a shortage of talent, which is scouted worldwide

The ethical and legal implications of AI are being debated

institutions to study the long-term implications of artificial intelligence in all aspects of life.

At the Stanford 'Artificial Intelligence Lab' and 'The Vision Lab', researchers focus on computer and human vision. They learn computers to analyse images, understanding patterns, get meaningful interpretations and develop intelligent algorithms. Further research is done in object recognition, scene categorization, integrative scene understanding, human motion recognition, material recognition and the underlying neural mechanisms that enable the human visual system to perform high level visual tasks with speed and efficiency.

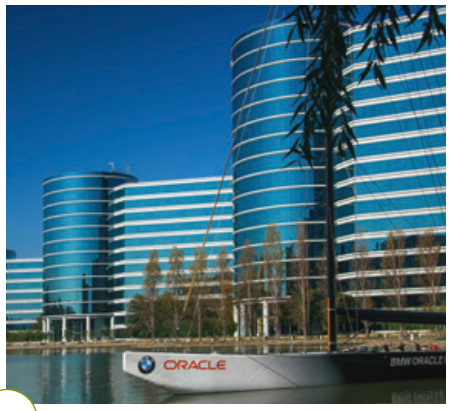
The Vision Lab is headed by associate professor Fei Fei Li. She addresses the need for education in AI (with the AI4ALL program) and promotes diversity and fair representation of women in the field to get to better AI results.

UC Berkeley offers the 'Berkeley Artificial Intelligence Research' (BAIR) program. In this program over 100 (student) researchers are focusing on 3D model recognition issues with 3D prediction learning modelling. Another angle that they study is the humanities perspective of 'value alignment problems', how humans interact with computers and the difficulty to state specifically what 'we' want and how to learn from that to develop safer designs for AI.

Debate on ethics and regulation

Scientists and entrepreneurs are debating the implications of artificial intelligence. Research and tech industry heavyweights have very different views on AI. The late Stephen Hawking (University of Cambridge), Elon Musk (Tesla, OpenAI, Neuralinks, SpaceX, Hyperloop, Paypal) and Bill Gates (Microsoft) have repeatedly warned about the dangers of IA, describing it as a potential threat to human existence. Others, like Mark Zuckerberg (Facebook), Larry Page (Google) and Ray Kurzweil (Singularity University) are very optimistic about AI and see a bright future. Some even see a future with seamless integration of humans and robots into a new species.

Recently, a Stanford University study on AI sparked the growing debate in AI ethics and



regulation. Two researchers experimented on how artificial intelligence could identify people's sexual orientation based on one's face with an 80% accuracy. The researchers defended their work by saying that they had studied existing technologies that are already widely used by companies and governments, and that they wanted to alert the public about its dangers.

According to ethicist Jake Metcalf of Data & Society, more social scientists are using AI intending to solve society's ills, but they do not have clear ethical guidelines to prevent them from accidentally harming people. This controversy shows the need to develop standards for the use of AI and data science.

A debate between tech titans Elon Musk and Mark Zuckerberg triggered the debate on AI regulation. Elon Musk pushed for the proactive regulation of artificial intelligence at a U.S. governors meeting: "I keep sounding the alarm bell, but until people see robots going down the street killing people, they don't know how to react, because it seems so ethereal". Mark Zuckerberg, disagrees with these doomsday predictions: "I think you can build things and the world gets better. But with AI especially, I am really optimistic. (...) AI is going to deliver so many improvements in the quality of our lives.". Elon Musk responded the next day on Twitter: "I've talked to Mark about this. His understanding of the subject is limited."

A debate is going on about how to develop and control AI. Should it be developed open and accessible to all or in the contrary should it be developed in a closed academic and corporate environment, only accessible to experts until we understand how to control AI?

Open AI

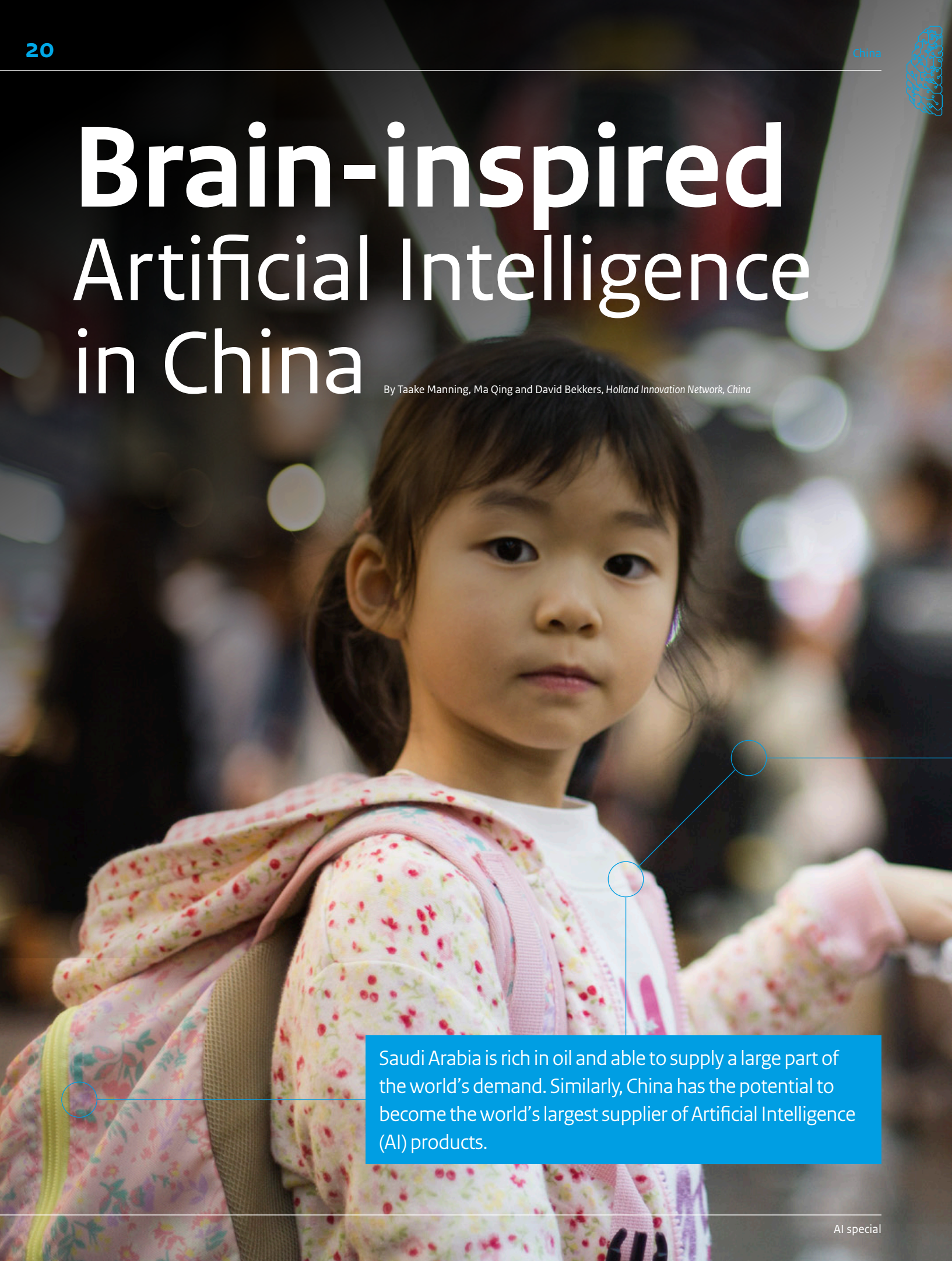
In October 2015, the start-up OpenAI was announced by Elon Musk and Sam Altman (Y combinator). Together with investors they set up OpenAI pledging over USD 1 billion. OpenAI is a not-for-profit artificial intelligence research company that aims to promote and develop friendly and safe AI in such a way as to benefit humanity as a whole. The organization aims to 'freely collaborate' with other institutions and researchers by making its patents and research openly available to the public. With OpenAI they want to create a new kind of AI lab, operating outside the control of the large corporates and release AI knowledge to the public.

Essentially, OpenAI is a research lab meant to counteract large corporations who may gain too much power by owning super-intelligence systems devoted to profits, as well as governments which may use AI to gain power and even oppress their citizenry. One of the advantages of a totally open program is that the labs can collaborate with anyone because they can share information freely, discovering and enacting the path to safe artificial general intelligence. OpenAI conducts fundamental, long-term research toward the creation of safe AGI.

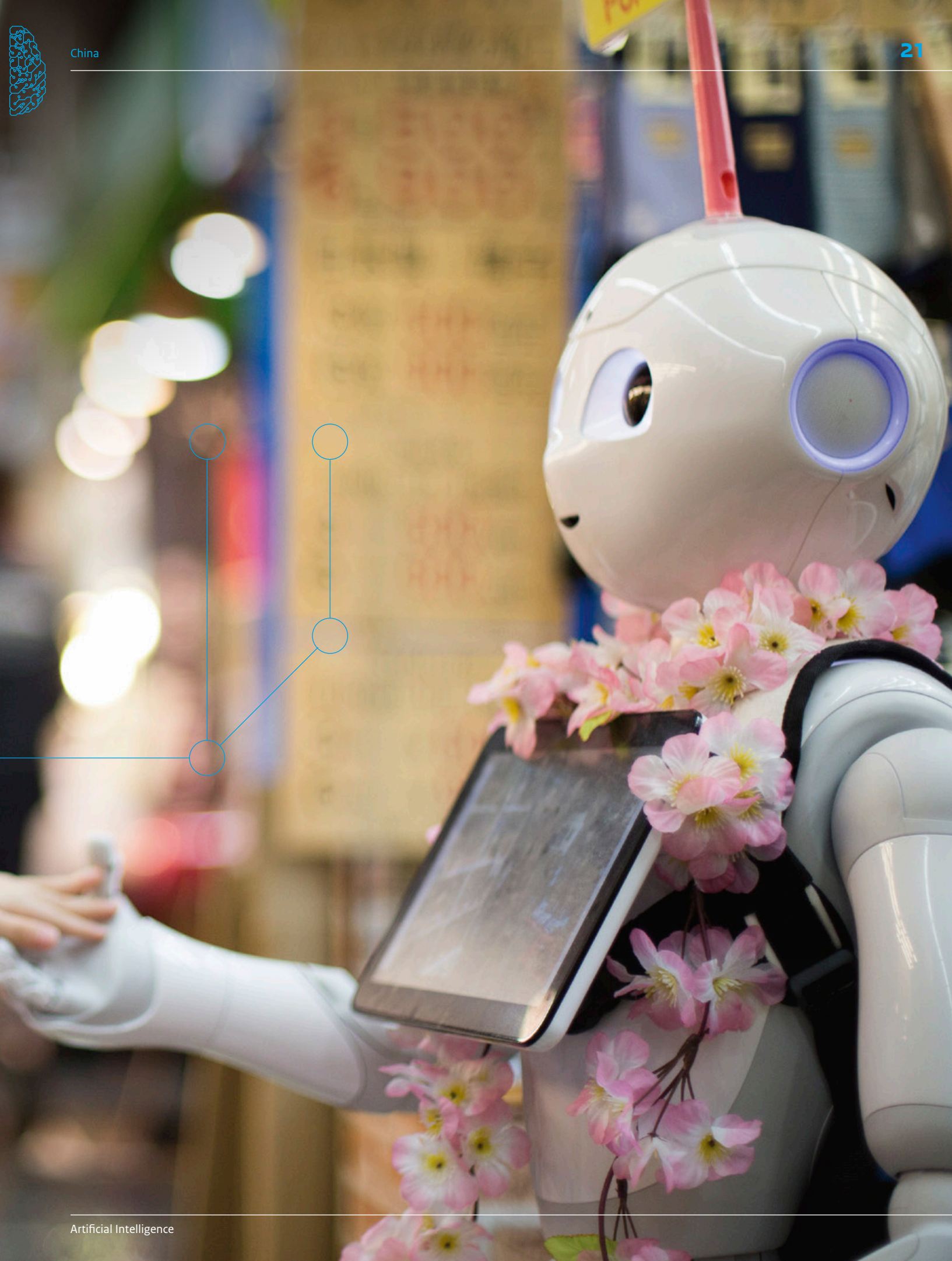
Many tech companies such as Amazon, Microsoft and LinkedIn cooperate with OpenAI and are contributors or project sponsors.

Brain-inspired Artificial Intelligence in China

By Taake Manning, Ma Qing and David Bekkers, *Holland Innovation Network, China*



Saudi Arabia is rich in oil and able to supply a large part of the world's demand. Similarly, China has the potential to become the world's largest supplier of Artificial Intelligence (AI) products.



Consider the inputs needed for AI: access to capital; cheap, easy-to-get (cloud) computing power; a large pool of university-trained IT specialists; and, above all, lots and lots of data. China has it all.

The volume of data is particularly striking. China has at least 750 million mobile internet users eager to experiment and explore the possibilities that a connected life offers. Most of them use apps belonging to the three largest ecosystems: Tencent, Alibaba and Baidu. Also, the government and public services are avid collectors of information.

Large investments in AI

China invests heavily in the development of AI technologies and products, and with good reason given the societal challenges it faces. The country has a population ageing at an unprecedented rate. At the same time, its education system is struggling to train young people in the volume and to the level and skills needed. China is a middle-income country with the incidence of non-transmittable diseases of a rich one, especially lifestyle-related diseases. It is a rapidly urbanizing society but it struggles to keep people and goods moving in its cities. AI can play a role in meeting these challenges, for instance with better diagnoses and monitoring of a patient's or elderly person's behaviour. China expects AI technology to play an important role in the country's industrial development as well. For example, it aims to be a smart industry and intelligent vehicle superpower by the year 2025.

In terms of quality of AI science, China is on a par with the world average

Chinese AI policy

The Chinese government is creating a policy framework to foster a healthy environment for AI development. Main building blocks are a 15-year long-term national policy paper and a 3-year short-term Action Plan.

In the long run, China aims at catching up with world leaders in AI technology and applications by 2020. It expects to make breakthroughs in basic research on AI theories by 2025. The final goal is for China to become a 'premier global AI innovation center' in 2030. In quantitative terms, the 15-year policy paper envisages China's core AI industries reaching 1 trillion Yuan (USD 159 billion), driving surrounding industries to exceed more than 10 trillion Yuan (USD 1590 billion) by 2030.

Large-scale research projects

To develop enabling technologies, large-scale research projects will be set up. These are called National Key AI Projects, with focuses on big data, cloud computing, brain-inspired AI, quantum-accelerated machine learning as well as brain sciences. Policy support also includes earmarked funds, talent training and an improved business environment. In parallel, the government is taking measures to reduce the impact of AI on the labour market as well as addressing the legal and ethical challenges this new disruptive technology implies.

In the near term, the 3-year Action Plan sets targets in more detail for a number of AI products and applications, such as intelligent connected vehicles, robots and AI-supported medical diagnosis. Smart sensors, neural network chips and open source platforms will be supported to form AI infrastructure. Measures will also be implemented to build industry clusters, key laboratories and encourage data sharing.

Table 1: largest research institutes in brain-inspired AI

In comparison, the largest institute in Europe is Imperial College London with 165 publications.

University / Research Institute	*Publications*	*Main Department*
Institute of Automation CAS	416	Research Center for Brain-inspired Intelligence
Huazhong UST	381	State Key Lab of Image Processing and Intelligent Control
Southeast University	342	State Key Lab of Computer Network and Information Integration
Harbin IT	292	School of Computer Science; Department of Computer Science Shenzhen Graduate School
Tsinghua University	257	Tsinghua National Laboratory for Information Science and Technology
South China University of Technology	245	School of Computer Science
University of Electronic S&T	240	State Key Lab of Neuro-information

China is the world's largest producer of scientific publications on AI. Already in 2015, the Science and Technology Policy Office of the White House was alarmed and reported China was eclipsing the US in deep learning and neural networks research. China also accounts for 23% of the world's patents in AI. In terms of quality of AI science, China is on a par with the world average, with local hotspots where scientific quality is comparable with or better than in the West. One of these is brain-inspired intelligence.

Brain-inspired AI

From a technological point of view, brain-inspired AI is one of the most exciting AI areas. Essentially a bio-mimetic science, the subfield draws from knowledge about how our brain works to construct better working AI systems for specific purposes. It tries to translate results of neurosciences, where knowledge has often been obtained with the goal of curing diseases in mind, to useful computer programs or hardware.

At present, the most popular applications of brain-inspired AI are neural and deep neural networks, with prominent examples like Deep Mind (Alphabet/Google) and reinforcement learning, having shown its worth in many applications for AI.

Brain-inspired AI is particularly strong in complex, non-linear environments. Once properly trained, a brain-inspired AI system can also be very *attentive* – meaning that it can very quickly select the most important information from a huge stream of input signals. Weaknesses of such systems are that they require a lot of data and computing power to learn and, because of their flexible nature, offer little insight in underlying processes.

It is therefore no surprise that systems such as these are used in applications where plenty of complex data is available and the output can be rather fuzzy, such as in image recognition and natural language processing. Next to that, simulating brains at different scales can be necessary for self-organizing systems with many functions.

In brain-inspired AI, China is a world leader in numbers of scientific publications and patents. The Chinese jurisdiction accounts for 48% of all patent applications worldwide from 2007-2016, compared to 23% in AI in general. These numbers highlight brain-inspired AI has a special focus within China. Table 1 and 2 display the largest scientific institutions and Chinese jurisdiction patent applicants in the same period.

The prevalence of universities among the patent applicants shows that this field is still very much academic in China, but is heading towards applications fast.

The Research Centre for Brain-inspired Intelligence under the Institute of Automation of the Chinese Academy of Sciences (CAS) is one of the hubs from where this will most likely happen.

See the interview with professor Zeng Yi for more information on their activities.

In brain-inspired AI, China is a world leader in numbers of scientific publications and patents

Table 2: largest patent applicants within Chinese jurisdiction in brain-inspired AI

Only full utility patents included.

University	*Patent Applications*	*Granted Patents*
Xidian University	113	46
Zhejiang University	110	38
Tsinghua University	103	16
Beijing Institute of Technology	95	18
Tianjin University	76	16
Beihang University	73	49
Southeast University	69	16
Company	***Patent Application***	***Granted Patents***
State Grid Corp. China	250	24
Qualcomm Inc.	61	12
Jiangsu Electric Power Co.	23	<10
Sichuan Yonglian Co.	20	<10
Sony Corp.	17	22

Prof. Zeng Yi

Vice Director | Research Center for Brain-inspired Intelligence, Institute of Automation, Chinese Academy of Sciences

Trying to make an even better conscious brain for robots

What do you hope brain-inspired AI will bring in the future?

Most efforts on brain-inspired AI in the world focus on a better learning system. While brain-inspired learning is of course important, it is not the whole story. My ultimate goal for brain-inspired AI is to build a Brain-inspired Cognitive Engine (BrainCog) for future machine and robots. BrainCog should enable intelligent machines to have various cognitive functions (at least 150 cognitive abilities at different scales) and autonomously coordinate in a self-organized way. In addition, it should enable future robots to be living conscious individuals in our society.

What are the biggest advantages compared to general AI?

Brain-inspired AI aims at realizing artificial general intelligence through building an intelligent model inspired by the brain from the structure and working principles perspective. Most of the current AI models focus on building a model to fit a certain type of task or even dataset, not really on building biologically realistic AI models. To me, brain-inspired AI is seeking to realize intelligence through computationally reverse engineering the brain and mind from some perspectives, and trying to make an even better conscious brain for robots.

What do you see as the major challenges?

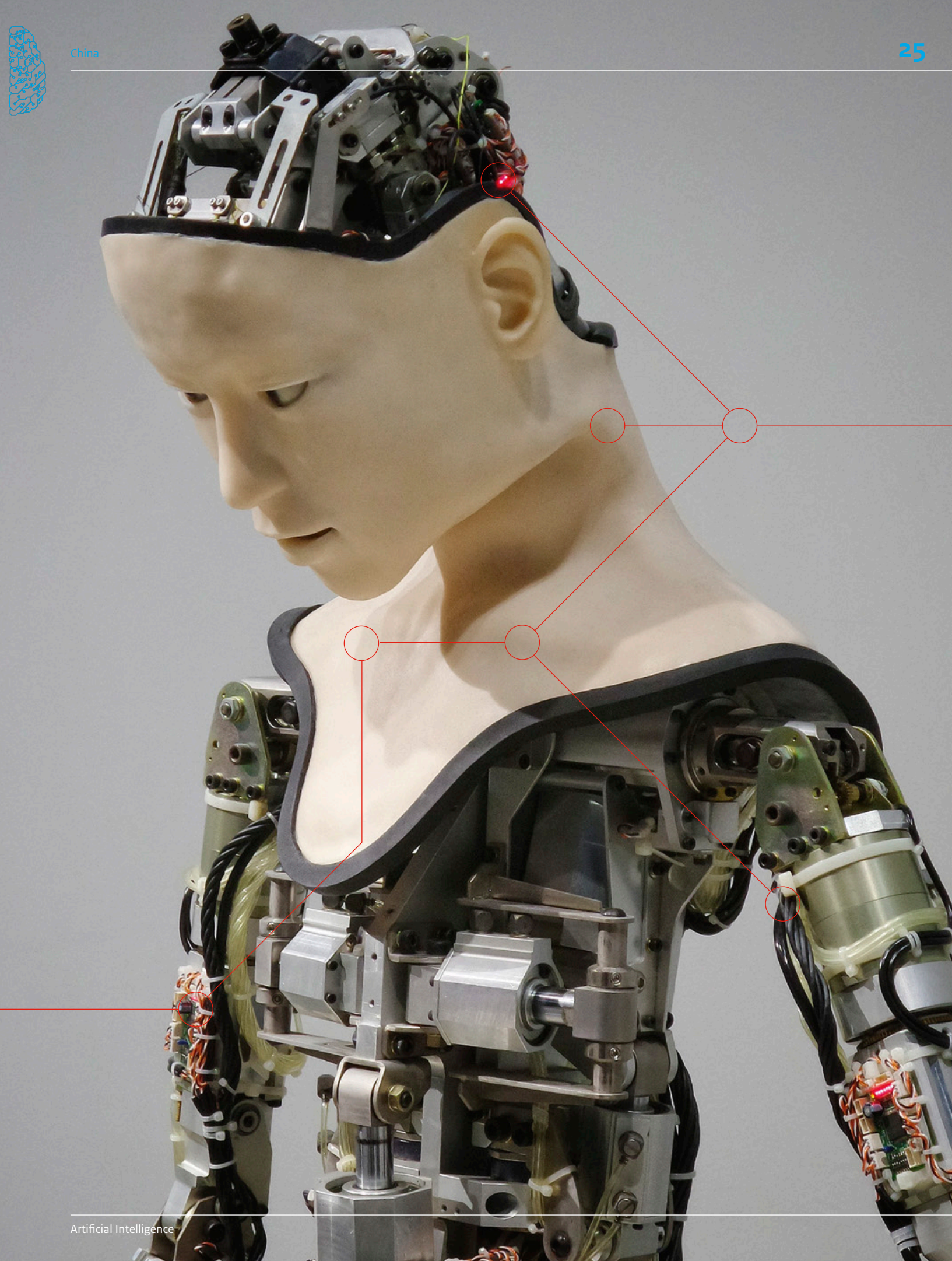
There are many grand challenges. Currently, a major question is how to self-organize more than 100 cognitive functions to solve very different kinds of problems. Next, and this seems to be philosophical but is actually very practical, can we realize a truly conscious robot, and in which way can we ensure the robot is conscious? What is the difference between conscious and unconscious robots? Last but not least, with a brain-inspired cognitive engine, can a robot really be living in our society, instead of just existing?

How are you cooperating with companies?

I am interested in deploying our brain-inspired models for various kinds of robots, especially social robots and service robots. I am also seeking collaborators who are visionary to build truly conscious robots.

Who do you work with internationally?

We have collaborators at the Allen Institute for Brain Sciences (USA). We also have a long history of cooperation with the knowledge representation and reasoning group at Vrije Universiteit Amsterdam, led by prof. dr. Frank van Harmelen. We would be very happy to develop potential collaborations with universities and institutions from the Netherlands.



First applications

Brain-inspired AI such as neural networks have already led to a number of successful commercial applications in China.

Facial recognition technology is now accurate enough for commercial use in China. Face++ has technology that can authorize payment using only face as credentials through Alipay (a popular mobile payment app developed by Alibaba).

Jingdong, another e-commerce giant, is testing this convenient 'show your face only' payment method in several offline shops in Beijing.

Apart from secure and convenient payment, face recognition technology is also developed for surveillance purposes. The police can use the system to identify suspected criminals in video captured by surveillance cameras.

Chinese search engine Baidu is working on applications that provide tourists access to tourist destinations without a ticket but by scanning and matching faces.

Another group of Chinese AI companies is specialized in intelligent speech and language technology. iFlyTek is leading in areas of speech recognition and text-to-speech conversion. The technology is used in popular personal assistance services (similar to Apple's Siri). iFlyTek also developed an intelligent speaker called Dingdong. By talking to it, one can easily control smart devices at home, in a similar fashion to Google Home.

Baidu also tries to advance AI technologies with its tremendous data collection and data processing power. Last month, the company's driverless car was tested in full autonomous driving mode under mixed road conditions in Beijing. Backed by machine learning technology and vast amounts of data, it succeeded in several challenging manoeuvers including U-turns, changing lanes and joining the traffic from a ramp. This car is said to be available on the consumer market as early as 2020.

On the hardware side, Huawei has incorporated an AI-optimized chip on their Mate 10 telephone, with assistance of CAS Institute of Automation spin-off Cambricon (now valued at USD 1 billion).

Highlight projects Prof. Zeng Yi

BrainBo
Application of the Brain-inspired Cognitive Engine (BrainCog) developed by the group in a variety of robots, for example for obstacle detection and avoidance in unmanned aerial vehicles, human interaction, reasoning, mirror test, etc. See https://www.youtube.com/watch?v=tMBVqUaaeeI for a collection of videos of a robot performing various tasks using BrainCog architecture.

Brain-inspired cognitive engine (BrainCog)
Brain-inspired cognitive engine, a project to build brain-inspired neural network based platform for simulating the cognitive brains of different animal species, supporting investigations of development and evolution, and realizing brain-inspired Artificial Intelligence. See http://bii.ia.ac.cn/braincog/

Linked Brain Data (LBD)
An effort for extracting and synthesizing distributed knowledge about the brain from multiple disciplines and sources, and using them to answer questions on what we have known, and what we can predict about the brain at multiple scales. See http://www.linked-brain-data.org/

Opportunities and threats for the Netherlands

Data has been one of the most important elements for commercial AI. Tremendous amounts of raw data are created every day in China. Access to data has been relatively easy. The Chinese people are less concerned about privacy issues. Often, they are not fully aware of how data carrying their personal information are used and for what purpose.

Easy access to raw data in China can be an opportunity for Dutch AI research and technology developers. But sometimes it is not as easy as it seems. A big portion of data is created by consumer electronics, such as people's mobile devices. Such data is gathered by the big companies that developed the mobile apps or online platforms. The way personal and financial data, purchasing behaviour, whereabouts and much more can be retrieved from a single app such as Tencent's multipurpose chat app WeChat is unmatched in the West. It is hard to get access to such data, and even harder to compete against it.

Another significant part of data is in the hands of the government, where it is often kept confidential. Examples are advanced demographic, economical, meteorological, water and soil, and remote sensing data. The recent digital policy of China advocates for cross-sector data-sharing within different government agencies and with the public. To what degree AI players can benefit from such a policy still remains to be seen.

The recently published Chinese Cyber Security Law has imposed strict rules on cross-border data flow, data localization, and approvals required for companies handling significant amounts of consumer data (in short, data created in China will stay in China). These rules apply both to domestic and foreign companies, which might cause complications for joint AI R&D activities with and in China.

The Netherlands needs to keep a close eye on the development of China's data policy, complying in a way that does not compromise the Dutch party's interests.

Conclusion

China is determined to lead the world in AI. Both private sector and government invest significantly. Big internet companies and startups have a large consumer market of open-minded Chinese people at their disposal. People who are used to constantly embracing new technologies and the convenience they bring, and less concerned about privacy. Next to that, China has the big advantage of a well-protected abundance of data and a well-trained research staff. In such a situation, it makes sense to join forces with Chinese partners as opposed to setting up shop independently in China. Even outside of China, it is likely that Chinese parties will increasingly leave their mark in various applications of AI, and in areas such as brain-inspired AI.

Cross-Sector Cooperation in Germany

In Germany, the private sector, government, science ánd society have a shared belief that Artificial Intelligence (AI) is of great strategic importance for the future. Its potential impact on product, process and labour will be enormous. Cooperation across sectors is key in Germany.

By Bart Sattler, Joop Gilijamse and Lars Kramer, *Holland Innovation Network, Berlin and Munich*

Economically speaking, Germany is strongest in sectors which are and will be impacted the most. These include the automotive industry, the financial sector, the manufacturing industry, the renewable energy sector, medical technology and health.

In view of the strategic importance and the wide range of applications of AI, a great many actors are involved. The federal as well as the state government enact new regulations and stimulate research and development. The scientific field includes several renowned institutes and is carrying out a diverse array of research programmes. The private sector, for multinationals down to SMEs recognize AI's relevance to their competitiveness.

Major actors

Bundesministerium für Bildung und Forschung (BMBF)
Under the previous government Merkel-III, federal innovation policy took a giant leap forward. The *neue Hightech-Strategie* introduced an additional package of investments, focusing on six fields of research with great societal impact. 'Digitization' is one of its central themes. In May 2017 then-minister Wanka announced a new research programme focusing on learning systems, next to the existing 'Industry 4.0' programme. This includes ethical, social and legal aspects and is supposed to bring about an ethical and legal framework from which to apply AI more easily. The *Plattform Lernende Systeme* aims to stimulate the entire R&D chain, ranging from fundamental research to demo projects. BMBF explicitly mentions AI in mobility, health, production environment robotics as well as in human-unfriendly environments, and cyber security.

Bundesministerium fur Wirtschaft und Energie (BMWi)
For BMWi also, digitization is a strategic theme. Earlier, it drew up the Digital Agenda 2014-2017, with digital infrastructure (broadband internet), secure digital communication and the digital economy as central elements ('*Made in Germany wird Digital*'). The superseding Digital Strategy 2025 describes measures and instruments necessary for a successful digital transition. BMWi strives for a level playing field, safeguarding individual constitutional rights and the protection of data. Part of the digitization strategy is the *intelligente Vernetzung* initiative, which started a societal dialogue in June 2017. Questions debated include AI's potential for cities, companies, startups, education and research organizations.

Bundesministerium für Arbeit und Soziales (BMAS)
The digital transition raises all kinds of labour-related questions. For example, the new urgent need for more specialized knowledge workers. AI will also have an impact on how work is organized and the ways in which we work. BMWi, BMAS and the *Bundesministerium der Justiz und für Verbraucherschutz (BMJV)* have written a joint position paper with a view to stimulating a societal debate on the balance between economy, labour and consumer protection. In it, policy visions are given for employers, employees and consumers.

Deutsche Forschungszentrum für künstliche Intelligenz (DFKI)
DFKI is the most important German research institute studying AI. It is also the world's largest research institute, measured in turnover and the number of researchers.

Over 800 people work in research centres in Saarbrücken, Kaiserslautern, Bremen, Berlin and Osnabrück.

At present, DFKI has 18 research themes, 8 competence centres and 7 so-called Living Labs, and is working on about 240 different AI-related projects. Funding comes from public means (European Union, national budgets of BMBF, BMWi, DFG and the federal states involved), and also from the marketplace, through contract research for (international) business.

A closer look at DFKI's scientific and oversight boards reads as a 'Who is who?' of the German high-tech manufacturing industry (e.g. BMW, Daimler), combined with renowned foreign companies such as Google, Microsoft, SAP, Airbus as well as SMEs.

Machine Learning is the basis of DFKI's work. Their Saarbrücken centre is working on 'body-near AI systems', used to receive and interpret bodily signals to keep people healthy, prevent heart attacks and recognize illness and disease before they manifest themselves clinically.
Another focus area of DFKI is so-called 'long-term autonomy' in an industrial setting. In the future, technical systems in the manufacturing industry will be able to improve themselves continuously. This will become essential for innovations in this sector. Much attention is given to 'hybrid teams' of several robots and humans working together – each contributing his or her 'personal' skills. ('Industry 5.0'.)

DFKI is also working on 'ultra-connectivity' or, put differently, objects becoming subjects.

Saarbrücken centre is working on 'body-near AI systems', used to receive and interpret bodily signals to keep people healthy

Photo © Siemens AG

Photo © Daimler AG

AI in automotive

Despite the negative consequences of 'dieselgate' the German automotive industry is in the vanguard of autonomously driving cars. In Germany every third private sector R&D euro is spent by the automotive industry, accounting for € 18 billion in 2014. The sector and its surrounding network of technical universities and Fraunhofer institutes employs over 100,000 researchers in automotive technology. Digitization and the implementation of embedded systems play an increasing role within the sector.

Governments hope for greater traffic security and improved traffic flow through smart sensors and communication technology. German OEMs (original equipment manufacturers) and their suppliers such as Continental, ZF and Bosch increasingly regard software and embedded systems as a core competence. The reason is that an ever greater part of a car's worth consists of advanced driver assistance systems and infotainment.

52% of all worldwide patent applications with regard to autonomous driving in 2010-2017 were submitted by German companies. The top 10 includes six German companies - four OEMs and two suppliers. 'The usual suspects' Tesla and Apple are not important in the patents arena and Google is in tenth place. The winner is supplier Bosch with a total of 958 patents, followed by Audi (516) and supplier Continental (439).

This overview shows the strength of German industry. In addition to technological competence, this also lies in the close cooperation between OEMs and their suppliers. These companies have specifically turned their attention to AI. When evolving from assistance systems for lane recognition or pedestrians to fully autonomous driving the volume of input and programming lines increases exponentially, in such a way that traditionally programmed systems reach their limits. This is where AI comes in.

Furthermore, as big volumes of data become available –such as photos of complex traffic situations in cities – it is now possible to develop deep learning systems capable of evaluating a moving car's environment. The *Karlsruher Institut für Technologie (KIT)* is involved in the *'Testfeld Autonomes Fahren Baden-Württemberg'*, where the federal state makes available € 2,5 million as well as 200 km of roads for research in the field of autonomous driving. Here research institutes can test all kinds of autonomous vehicles (public transport, logistical, personal) and accompanying services such as car sharing and other mobility apps.

AI in Life Sciences & Health

The market for medical technology in Germany is the third largest in the world. This sector employs over 200,000 people and had a turnover in 2016 of € 28 billion. With an ageing population and rising healthcare costs, the medical sector is expected to provide smart and efficient innovations. The growing volume of data from patients records, the increase in knowledge about disease development and the advent of personalised and precision medicine have turned medical developers' attention to AI solutions.

Siemens Healthineers in Erlangen is at the forefront of AI and Healthcare. For example, it has developed a system able to recognize ribs from tomographic thorax photos and produce a 2D image of it. Another Siemens application is producing a live animation during surgery, assisting a doctor who is placing a new heart valve. Cooperation with Fraunhofer has been instrumental in these developments. Fraunhofer MEVIS in Bremen is working on imaging systems able to recognize tumors at an early stage.

Robotics in healthcare is another interesting field. The company Kuka has developed the support robot Diana, which is helping nurses and doctors in hospitals, performing monotonous tasks. Lastly, startups have also entered the field, for example KI Elements, supported by EIT Digital and DFKI. It has have developed a speech recognition system for diagnosing neurological illness such as a small stroke or even Alzheimer's at an early stage.

This is next-level Internet of Things, where devices do not only measure and send data, but edit inputs through AI, learn from them and act accordingly.

Some of the 18 research themes and 240 projects most relevant for the Netherlands are: AI for robotics, smart retail technology, embedded intelligence, innovative systems for the manufacturing industry, smart service engineering, Internet of Things, big data analysis, intelligent networks, virtual / augmented reality, real-time translation and human-machine interaction. DFKI's *Institut für Wirtschaftsinformatik* aims to valorize research outcomes, with specific focus on SMEs.

Fraunhofer - Institut für Intelligente Analyse- und Informationssysteme (IAIS)
Within the Fraunhofer organization for applied scientific research, AI research is mainly undertaken at the Institut für Intelligente Analyse- und Informationssysteme. There, around 600 scientists work on AI and related themes: deep learning, big data, multimedia pattern recognition and cognitive robotics.

The organization also houses the *Allianz Big Data*, where 29 of the 69 Fraunhofer institutes cooperate to reinforce research on and with big data. AI takes centre stage here: both for training AI systems with big data and to deploy AI for extracting useful information from large volumes of unstructured data.

The number of 80 AI startups is a reliable indication Germany has outgrown the fundamental research stage

Max Planck Gesellschaft - Institut für Intelligente Systeme
Within the Max Planck Gesellschaft – the German organization for fundamental scientific research – AI research is concentrated in the Institut für Intelligente Systeme, with locations in Stuttgart and Tübingen. Here, 11 research groups are working on perception, autonomous robotics, locomotion and intelligent nano-biotechnology (for nano-robotics, biosensors, microfluidics, self-organization).

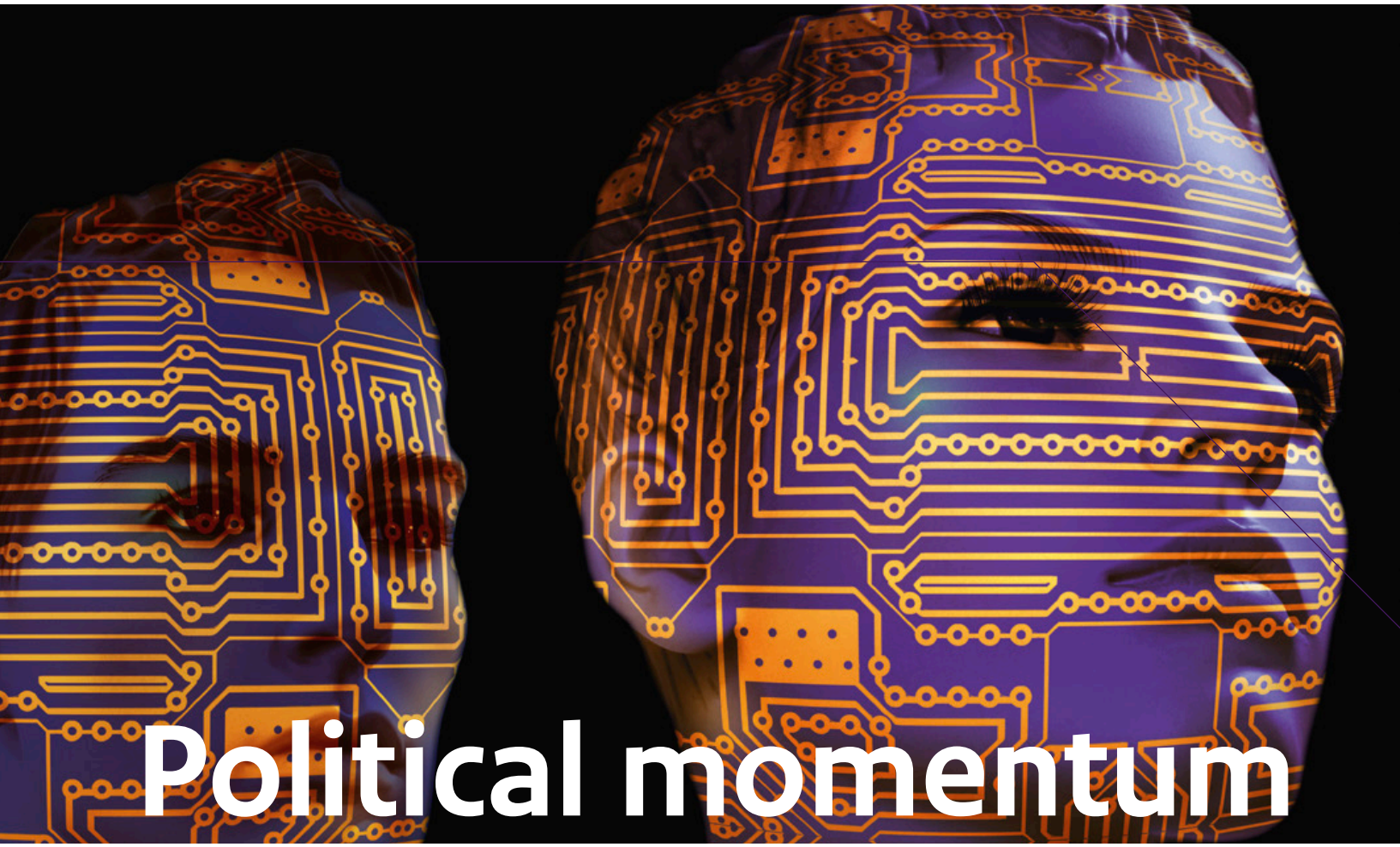
To market this knowledge, the Max Planck Gesellschaft and the federal state of Baden-Württemberg founded a 'Cyber Valley' with the International Max Planck Research School for Intelligent Systems. Special attention is given to training AI knowledge workers for the private sector and startups. Industry is also involved: Bosch and Daimler are financing two university chairs; Porsche, ZF Friedrichshafen, BMW and Facebook are partners.

The private sector
As set out above, there is much interaction on AI between the German government, knowledge institutions and private sector. An extensive study has shown that German industry expects the utilization of AI to generate rises in productivity.

Not so much by substituting human labour, but control over the amount of data, more efficient company and production processes as well as the support of specialized employees by AI systems. AI's impact is greatest in the automotive, manufacturing, financial and health sectors. Big data, robotics, human-machine interaction and intelligent automation and predictive analysis (for preventive servicing and quality assurance) will make all the difference in competitiveness. Its potential is connected to employees' skills in these sectors with relatively highly-educated personnel.

The number of German startups in AI is also a reliable indication that AI has outgrown the fundamental research stage. For example, DFKI has spawned over 80 startups who by their account have over 3,700 people in employment.

Developments in AI are closely followed by the likes of Siemens, SAP, Bosch, Continental, the large automotive OEMs as well as German high-tech SMEs, if they are not already heavily active in it.



Political momentum in France

By Danny Hoekzema, Django Beek, Nico Schiettekatte, *Holland Innovation Network, France*

'France is AI' is the platform uniting, representing and supporting all players in the French AI ecosystem. It has four main goals:

1. Create a dynamic environment for the AI community, together with its members;
2. Organizes the annual France is AI ongress to celebrate its community and to discuss research outcomes, new applications and societal challenges;
3. Financially support new initiatives;
4. Connect to other AI hubs (US, Canada, UK, Switzerland and China).

The French AI ecosystem:

- 68 R&D laboratories
- 230 public research teams
- 5,300 scientists
- 14,000 employees
- hundreds of startups

France has gained an international reputation with its renowned university studies in mathematics and informatics. On 29 March 2018, Emmanuel Macron announced his plan to intensively scale this breeding ground for fundamental and applied scientific research into AI. France is welcoming major corporations in AI and is readying an 'AI-budget' of € 1.5 billion.

AI source of innovation in French automotive

The automotive sector is experiencing three revolutions at once: the advent of electric, connected and autonomous vehicles. Artificial intelligence is crucial to these developments. It is centra lto applications across the production chain, from software development to after-sales. The value of software as a percentage of a car's value has increased from 3% ten years ago to 10% and will rise to 30% with autonomous cars.

French car manufacturers are also working on the autonomous car. At the beginning of 2017 PSA presented its 'Peugeot Instinct'. Renault has adopted an ethical approach to development according to the principles of 'privacy by design', in cooperation with the National Commission for Information Technology and Freedoms (Commission nationale de l'informatique et des libertés - CNIL).

Other players in the automotive sector are also working on AI applications. Supplier Valeo has announced its global research centre Valeo.ai – specialized in deep learning - , in order to attract a large international scientific community and to build relations with research centre at home and abroad.

There is a public-private cooperation under Partners in International Business, called 'Smart en Green Mobility'.

France aims to strengthen its position

Mid-2017, the French parliamentary agency for evaluating scientific and technological choices (*Office parlementaire d'évaluation des choix scientifiques et technologiques - OPECST*) published a political-ethical report on the possibilities, opportunities and considerations of AI. The main conclusion: France is already heavily investing in AI but intensification is desirable.

Renowned mathematician (former Fiels Medal winner) and Member of Parliament Cédric Villani was asked to lead the drafting of a national strategy for the development of AI. The resulting publication AI for Humanity along with an hour-long speech of Macron and the investment of € 1.5 billion underline France's AI ambition.

France aims to not only push nationally but at the European level as well. The French have marked four strategic paths: health, transport, environment and defence & security.

Current AI research

Worldwide France ranks third in AI and robotics research. Leading institutes are Inria (*Institut de Recherche en Informatique et en Automatique*, the French national ICT research institute) and CNRS (Centre National de la Recherche Scientifique , National Centre for Scientific Research). Inria has 8 research centre and 160 projects with an AI component, while at CNRS 600 scientists study fundamental mathematics and information science.

In the private sector, IA research takes place within companies such as Thales (aerospace, defence, ICT), EDF (electricity), Engie (electricity, gas), PSA (automotive) and Total (energy). In addition, the presence of renowned university studies in mathematics, informatics and 18 IA master studies ensures a large volume of young graduates. This has led to more foreign companies locating their R&D effort in France.

International companies

Recently, Facebook established its first international AI research centre in Paris. IBM, Microsoft, Sony and Huawei did so earlier. Facebook also recently announced its selection of the first twelve French big data and/or AI startups participating in the Facebook Startup Garage programme in its brand-new Parisian incubator Station F. Microsoft, which is a partner in the Station F project, recently announced its first AI programme in cooperation with Inria.

This trend leads to an AI ecosystem growing stronger and stronger. The Paris Machine Learning Group with 4,000 members, for example, is one of the largest international meetups in the world. This reinforces France's attraction.

Ethics and values

A remarkable detail of the French AI strategy is the focus on the ethical part of the technology. The importance of it is underlined in the entire piece, hence the name *AI for Humanity*. At the end of 2016, the Law for a Digital Republic was adopted. It obliges parties active in AI to seriously consider ethical and societal problems of the application of AI. Respect for privacy, protection of personal data, transparency, responsibilities of institutions and contributing to collective awareness all have to be taken into account.

This has been extended with the goal of the national action plan being the welfare of the people, explicitly not (private) profit. The strategy takes the impact on labour into account by new methods of complementarity between human and machine, setting up a lab to investigate the transformation of labour. These and many others must ensure that AI supports inclusivity and diversity: it must not become just another technology for the wealthy and prosperous, as it has the potential to help all. The use of AI for a more environmentally-friendly digital world is also an important subject.

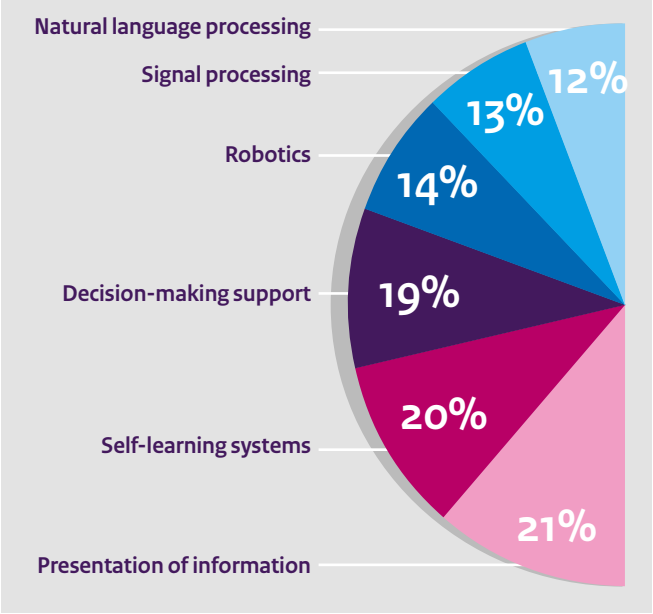
France has already sought cooperation with Germany. There also is informatics cooperation with the Netherlands, for example in the

DREAM project as part of Horizon 2020. This research project aims to provide robots with the opportunity and time to process information (so-called 'dreaming'), in order to arrive at higher levels of autonomy and knowledge. The April 2018 initiative European Lab for Learning and Intelligent Systems (ELLIS) seems a promising roadmap for joining public and private forces with the potential to generate economic impact and create jobs. Among the organizations subscribing to the ambitions of ELLIS are INRIA, CNRS and the University of Amsterdam.

Conclusion

The strong AI ecosystem, current political momentum and continuing internationalization of the French AI sector provides opportunities for Dutch actors with AI expertise. The experience the Dutch have in public-private partnerships (PPP) holds great potentialfor strengthening AI cooperation with France, both in a bilateral and a greater European context.

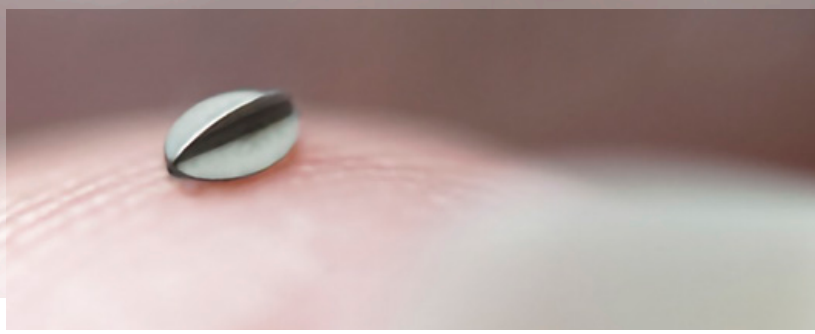
Application of AI in France



Sectors and priorities AI	*Companies and projects*
Aerospace and space Developing autonomous system (airplanes, [imagery - speech], satellites) and their movement in air/space). Automation of production and service of platforms and systems. Supporting design of complex products (decision-making for designers).	Airbus - airplanes and helicopters on demand. Airbus Smarter Fleet (with IBM) Production: robots/humanoids (project FUTURASSY with Kawada). Automated inspection. Detection through satellite imagery (with Google, project OneAtlas) Thales - Cybersecurity. Smart air traffic Safran - Autonomous piloting system for combat aircraft
Banks and insurance companies Investigation and analysis of clients (in support of decision-making). Anti-fraud systems.	Crédit mutuel - cooperation IBM Watson BNPP - investing in Smartly.ai (chatbot). Cooperation Critéo SG - support decision-making Axa - setting up research fund for AI and big data reliability projects
Energy and environmental control Security industrial parks. Smart cities - use of client data with smart sensors (smart grid and Internet of Things).	eDF - development of smart networks (smart grids) Veolia - intelligent waste collection and sorting (with Huawei)
Distribution, luxury and tourism (B2C) Support in search for products/services and of decision-making. Optimization of product placement through various channels.	L'Oréal - investments in predictive systems and relations management. Accor - [intégration moteurs AI - AI motor integration] for CRM and advanced marketing. Publicis - Cyc-system for decision-making support
Transport Client analysis. Development autonomous systems.	Alstom - investments in autonomous shuttles EasyMile Renault/Valéo - development autonomous driving systems. Investment in smart sensors. PSA - prototype of self-driving car Picasso C4
Telecom Optimization of network control. Automatic development and maintaining of client relations. Client interfaces (chatbots, [box en connexion avec l'environnement]).	Orange - applying self-learning systems in client relations and call centres Bouygues - monetizing data and anti-fraud systems Nokia - improving location services, programming and automating network.
Health Development of more efficient treatments. [exploitation de données santé clients adaptées - processing of applied client data]	Sanofi - joint venture Onduo (with Google) to combat diabetes. Cancer treatment with IBM (Watson). Access to data on 118 diseases and illnesses with FDA. Dassault Systèmes - Optimizing R&D process (consortium BioIntelligence, with Ipsen)

AI in the UK:
fertile ground for business

It is fitting that one of the quirkiest moments of 2017 saw a Harry Potter novel written by a predictive AI algorithm. Fitting, not only as it demonstrates the broad potential of applying AI, but more so because of a keen feature included in most Harry Potter novels: Platform 9 ¾ at King's Cross station, London, where his magical journeys often start.



By Martijn Verwegen, *Holland Innovation Network, London*

In the area surrounding King's Cross station, known as the Knowledge Quarter, a vast concentration of world-class knowledge, private investment and government backing has created Europe's largest, most successful and best-connected AI ecosystem. In this area, less than a mile in radius, at least two AI unicorns have emerged and many are poised to follow.

This is bolstered by several world-leading knowledge institutes working on AI and Data Science that are based here, including the recently founded Alan Turing Institute, that combines the efforts of the leading 13 UK universities in this area, and Francis Crick Institute, that applies these techniques in the life sciences domain.

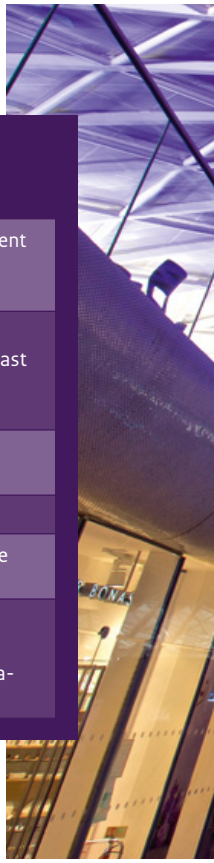
Adding an extra mile takes us to Whitehall, the heart of British government, where AI is at the forefront of parliamentary attention and government strategy. And, fitting with the theme, one hour express trains allow travel from London to Cambridge and Oxford, tying in their vast reservoirs of knowledge and innovation into this vibrant ecosystem. Best yet, the international trains from St. Pancras not only directly connect to Paris, but since April 2018 also to Amsterdam and Rotterdam, each with its own AI strengths.

UK ranks high in AI

In knowledge, the UK is ranked third in the world in scientific research output in artificial intelligence and machine learning. In business, the UK is ranked third in the world in private venture capital investment output in artificial intelligence and machine learning. In society, not a day goes by without a high-quality newspaper reporting on technical advances, societal challenges or ethical dilemmas related to AI.

In 2015, the UK launched the Alan Turing Institute, seeking to combine the country's considerable academic resources in artificial intelligence and data science. It has since grown to a collaboration of the 13 leading UK Universities in these fields and over £ 100 million in funding specifically for the Institute, excluding industrial collaborations. Over 300 researchers are directly associated with the Institute and thousands more benefit through its programmes, work-shops and outreach activities. Anything not covered by the Institute or its academic partners is likely to be covered by the efforts of the applied science and industry oriented Digital Catapult or the Open Data Institute just down the road.

And the best part? Its aimed at developing the next generation of AI, based on a network spread throughout the knowledge quarter and the UK.



A quick glance at some of the UK universities that have pooled resources to found the Turing Institute and some of their core expertises in AI and its application

UCL	Machine Vision, Machine Learning, Machine Reading and Knowledge Representation. UCL's department of computer science is considered the best in the UK and is contained within the London Knowledge Quarter.
Cambridge	Genomics and Bio-informatics, Computational Learning Theory, Computer Vision and Informal Reasoning. Cambridge is also home to the UK's most powerful academic supercomputer, with vast expertise in supporting non-traditional and industrial user groups and has just been awarded a major £ 10 million grant to make it available for AI technology companies.
Oxford	Robotic Technology and Autonomous Systems, Machine Learning, cooperating AI Systems, Computer Vision, Medicine and Healthcare
Warwick	Biomedical Imaging, Policy Support, Human Behaviour, Complex Networks
Edinburgh	Knowledge Representation and Reasoning, Artificial Learning Systems, Computer Vision, Mobile and Assembly Robotics, Music Perception and Visualization
Imperial College	Probabilistic Models and Approximate Inference, Reinforcement Learning and Online Learning, Deep Learning, Optimization, Causality, Computational Learning Theory, Robotics and Control, Computer Vision, Speech, Text and Natural Language Processing, Security and Privacy, Computational Social Science, Neuroscience, Bioinformatics and Systems Biology

Fertile ground for business, entrepreneurs and investors

DeepMind, VocalIQ en SwiftKey rank amongst the largest startup acquisitions of the past few years, with a combined estimated price tag of over € 1 billion, or € 2.5 million per AI expert. Each born out of the UK's vibrant DeepTech and AI scene. The list of UK AI-driven startups grows by one a week, with many of them attracting € 10s to € 100s of millions in funding within just a few years due to an extremely well-developed system of venture capital and angel investors with previous DeepTech expertise.

Just a sample of other homegrown UK AI businesses and their estimated value:

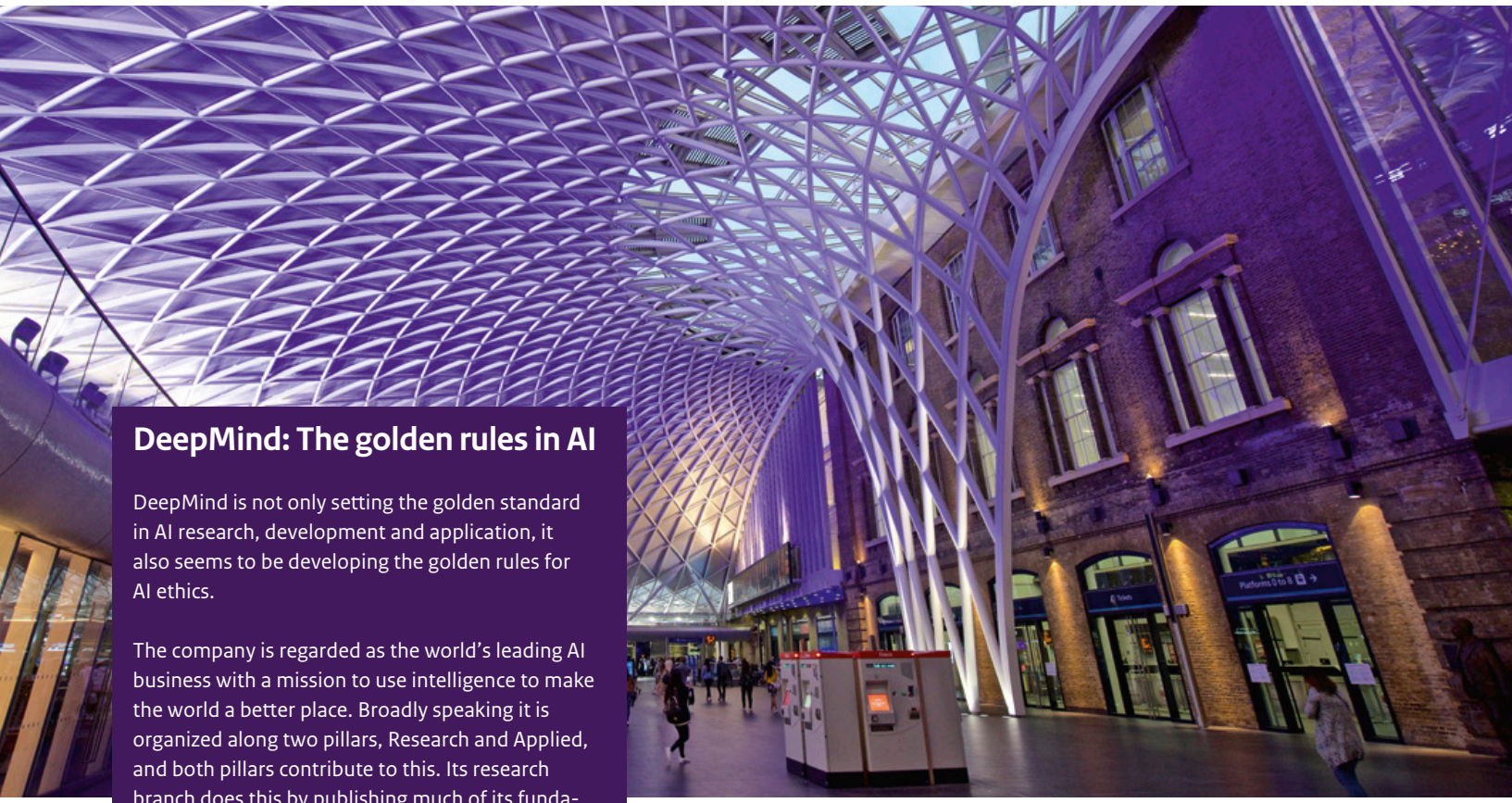
- Babylon Health (> € 100 million) for online doctor consultation and support, a system the NHS is testing as an alternative to visiting a doctor. Currently still with video consultation as a backdrop, but rumoured to be going for full autonomy.
- Darktrace (> € 200 million) that uses a pattern of life approach in networks to discover potential cyber threats before attacks can mature and before experts would be aware.
- Benevolent AI (> € 1600 million) which is disrupting the pharmaceutical industry by continually analyzing all of the world's life science research publications for patterns and opportunities. (As a new paper is published every 30 seconds, this goes far beyond what any human might be able to do). The results are licenced for further research development and the company is broadening its approach to reviewing publications in all technology areas.

This AI ecosystem is further fueled by the attention of large tech companies. The above-mentioned acquisitions by Google, Apple and Microsoft and others have largely seen further investment and strengthening of the associated AI research and developments in the UK. Other tech companies such Amazon and Samsung have likewise invested in research activities and expertise centers nearby to connect to this ecosystem.

Proactive government and an awakened society

The magic that AI promises is expected to transform all sectors of the UK economy and account for over 10% of its GDP by 2030, according to government estimates. Initial gains will likely be made in healthcare (surgery, imaging and diagnostics), autonomous vehicles, policy and decision support systems (financial, government, legal, crime), smart industry and robotics, and energy grid optimization.

As such the British government has placed AI first amongst the four great challenges that it believes will transform its economy under its new industrial strategy, stimulating investment in innovation. It should be no surprise that the government has allocated over € 650 million for developing the underlying DeepTech in its 2018 budget and in April 2018 announced a € 1,1 billion sector deal for further development. It seeks to further



DeepMind: The golden rules in AI

DeepMind is not only setting the golden standard in AI research, development and application, it also seems to be developing the golden rules for AI ethics.

The company is regarded as the world's leading AI business with a mission to use intelligence to make the world a better place. Broadly speaking it is organized along two pillars, Research and Applied, and both pillars contribute to this. Its research branch does this by publishing much of its fundamental work on Neural Nets, Deep Reinforced Learning and Differential Neural Computing (Pattern Recognition).

DeepMind Applied, however, goes far beyond. It consists of three core areas: DeepMind Health, to provide decision support to medical professionals; DeepMind for Google, to assist the technologies of its parent company; and DeepMind Ethics and Society, to ensure its work is of the highest ethical standards.

Their commitment to ethics seems real. Health has set up an independent review body of respected British public figures that have been given an unprecedented open role and widespread access to review DeepMind Health's activities and to scrutinize its work with the UK's National Health Service. To do this, they have formulated twelve principles that can be applied for ethical AI implementation.

Furthermore, the company engages five leading British academics to provide oversight, critical feedback and guidance on Ethics and Society's research programmes. Considering the prominent names that have committed themselves to both groups, DeepMind is well-positioned to be a leader in both AI and the ethical considerations it requires.

DeepMind is well-positioned to be a leader in both AI and the ethical considerations it requires

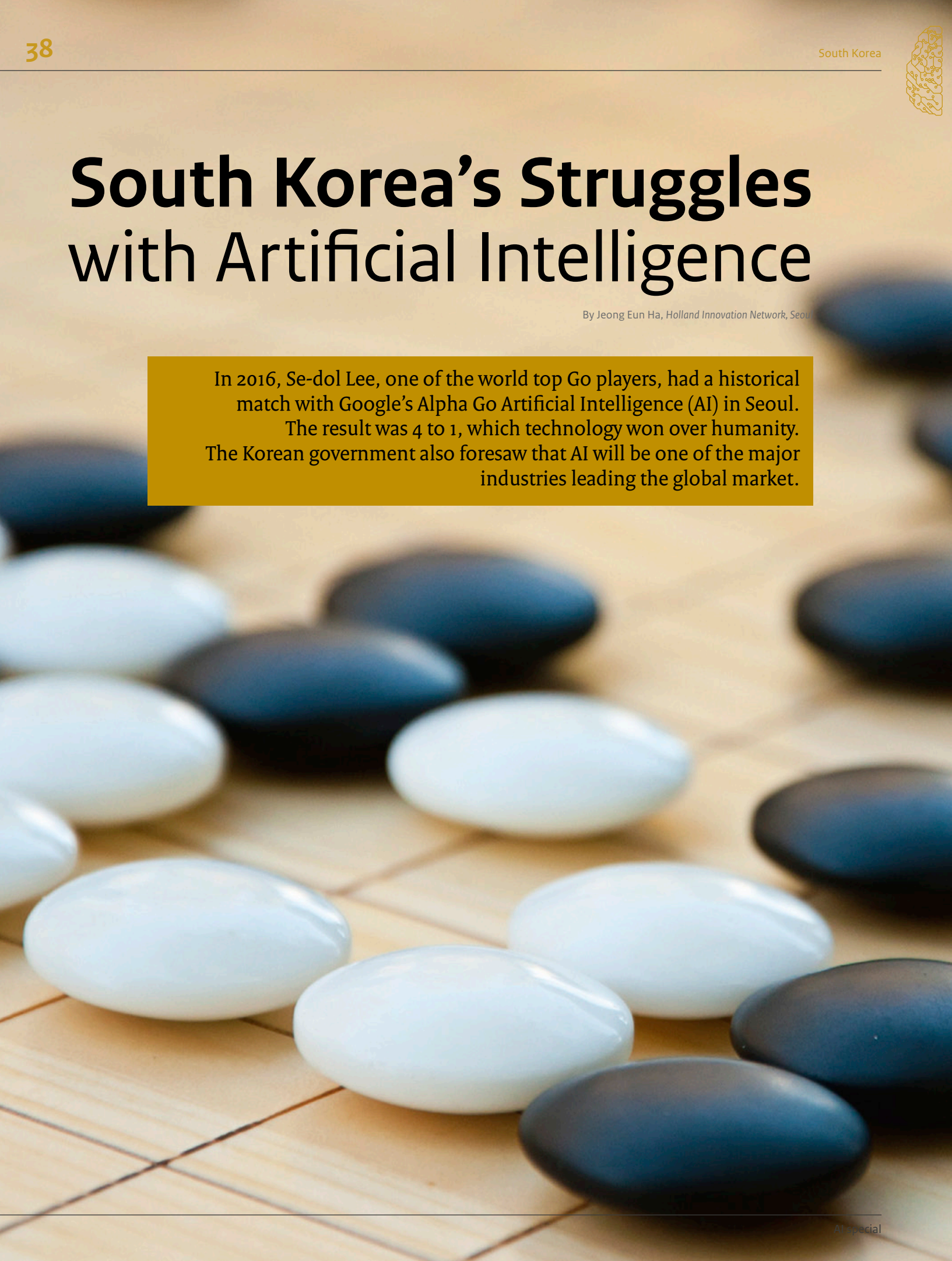
open up public databases such as those of the National Health Service. In healthcare, these records contain some of the most extensive and expansive record of patient health, due to the large populations unified in a single system and ongoing public efforts to gather additional data, such as the Genomics England's genetic profiles.

Of course, there are ethical concerns and discussions. To tackle these, both houses of UK parliament have undertaken extensive studies and expert hearings, leading to a multitude of recommendations on how such advances can be used for the benefit of all. The government has created a National Centre for Data Ethics and Innovation to ensure the UK will have standards to which AI developers will be held.

South Korea's Struggles with Artificial Intelligence

By Jeong Eun Ha, *Holland Innovation Network, Seou*

In 2016, Se-dol Lee, one of the world top Go players, had a historical match with Google's Alpha Go Artificial Intelligence (AI) in Seoul. The result was 4 to 1, which technology won over humanity. The Korean government also foresaw that AI will be one of the major industries leading the global market.



Korea is lagging behind because of strict privacy laws, the lack of big data, doubts about the application of AI and so on

While the United States, Europe and Japan are investing a lot of money in AI development, not much research has been done in Korea apart from its reputation of an IT powerhouse. Korea's market size in 2013 was approximately € 2.78 billion and is expected to grow up to € 4.94 billion in 2017.

Some of the large IT companies are investing in AI, but this is still fairly limited to some of the internet portal- or game-related companies. For instance, NC Soft (a large Korean game company) and NAVER (a Korean internet portal company) have been researching and developing AI for several years.

In 2015, Samsung Electronics acquired an AI startup called Vicarious and invested AI robot startup called Jibo. This indicates that Samsung Electronics is planning to do business in the AI industry. In addition, Samsung has collaborated with Wolfram Alpha to provide S Voice service for English-speaking countries.

The Ministry of Science, ICT and Future Planning (MSIP) has been investing in Exobrain software development from 2013. This software provides a knowledge reinforcement learning service by accumulating and self-learning the big data information. The investment is for a period of ten years to an amount of € 83 million euro. However, the amount of investment was very small when compared to that of the United States (€ 2.68 billion), Europe (€ 1 billion) and Japan (€ 794 million). The new Moon government has since pledged to invest € 1 billion.

Korean circumstances

There are several reasons why Korea is lagging behind in the AI industry. First, the main issue is the act on the protection of personal information. Companies are prohibited to use personal information of customers without their permission. Large companies are raising their voice to ease the regulation as they claim that this law obstructs the development of AI and big data industry. MSIP along with six other ministries will try to change the regulations.

Other than the regulation issues, companies claim they do not have big data which could be utilized for the development of AI; their companies are not large enough to analyze the big data, and there is no work that needs AI solutions. Also the CEO/CIO is often ignorant about the investment in AI and big data, there is distrust in the effectiveness of introducing big data in the company, and/or there is no specialist who knows what big data and AI really is.

A 'control tower' for AI

In March 2016, then-president Park invited 20 specialists in AI and software industries to the Blue House to hold a Government-Business joint conference on Intelligence Information Society. Park announced formation of a so-called 'control tower' of AI called the Science and Technology Strategy Committee. This control tower will aim to foster AI projects and funding plans.

MSIP will lead the task force and will plan a tentative roadmap. Total investment for the period up to and including 2020 will be said € 1 billion. The money will be used for funding R&D, employing specialists, investing in data infrastructure and fostering a convergent industry.

An additional € 1.9 billion will be invested by private sector companies such as Samsung Electronics, LG Electronics, SK Telecom, KT, NAVER and Hyundai Motors. Then-president Park encouraged the companies to establish a joint research lab for the development of AI industry.

This research lab will focus on five different fields of intelligence software. The development of language intelligence will be used for providing legal expert service, visual intelligence will be used for prevention of terrorism and city crime, space intelligence will be applied to drone lifeguard support, emotion intelligence will be used for elderly helper robot and summary & creation will be used for automatic contents summary service. For this flagship project, each company will invest € 2.3 million to establish the research lab, which in the initial stage will employ 50 researchers.

Sector	*Proof of Technology*	*Effectiveness in real life application*
Language Intelligence	World #1 in knowledge accumulation (by '19)	Law structure cost reduction
Visual Intelligence	Win #1 at ImageNet (by '19)	Percentage of crime reduction
Space Intelligence	Demonstration of Disaster relief (by '19)	Lifesaving within golden time
Emotion Intelligence	Demonstration of human interactive conversation (by '19)	Prevent death of senior citizens who live alone
Summary & Creation	Contest of summarize movie (by '20)	Increase contents consumption level

Life Sciences & Health and Agriculture sector in Brazil

Photo © Monsanto Company

By Rens Koele and Ernst-Jan Bakker, *Holland Innovation Network, Brazil*

Although at a smaller scale than in other countries, Brazil has several companies and research groups in the field of AI. Activities seem mainly geared towards application development using existing AI techniques. The Brazilian Society of Computation SBC has a special commission on AI (CEIA), which organizes annual events in this field (In 2017 with a speaker from the University of Utrecht). In the private sector, a group of 16 Brazilian AI companies created the Brazilian Association of AI (ABRIA) to collectively represent the sector. ABRIA estimates there are currently about 40 recently founded companies fully dedicated to AI. Applications are in sectors such as retail, marketing, education, health and agriculture. This article looks at the latter two sectors, given their importance in the innovation-related collaborations with the Netherlands.

Life Sciences & Health

In 2016 the University of São Paulo launched its Laboratory for Big Data and Predictive

In Brazil several research groups and companies are active in machine learning and artificial intelligence (AI). This article describes AI developments in Life Sciences & Health and in Agriculture in Brazil, since these sectors are among the most important in the (innovation) relation with the Netherlands.

Analysis in Health (LABDAPS). The project was funded by the São Paulo State research foundation FAPESP and the private Lemann Foundation. The lab's first project focused on tropical diseases, creating a preliminary diagnosis for diseases transmitted by the Aedes aegypti mosquito (dengue, chikungunya and zika), enabling a first screening without the use of a laboratory. Other projects are focused mainly on public health issues such as ageing and ICU priorities. LABDAPS's main goal is to reduce the spending of the public health system through machine learning and the better use of data. The Ministry of Health invested in data processing capacity through acquisition of supercomputers that will be able to unify the data of 4,400 municipalities. Besides unifying the data, the storage is ten times bigger and faster, which is relevant for future AI projects in the public system.
These public investments are in line with recent investments by Brazilian top private hospitals in cooperation with national and international partners. The Mãe de Deus Hospital in Porto Alegre was Latin America's first hospital to make use of IBM's Watson for Oncology, which is used to identify the best treatment for seven types of cancer. A group of 40 private Brazilian Oncology institutes, called Oncoclinicas, started a partnership with the University of São Paulo and Microsoft to develop a system analyzing patient data to determine the right doses of medicine.

Some high-level AI projects in hospitals have Dutch links. For example, the Brazilian AI company Kunumi, which opened its first international office in Rotterdam. Kunumi, is a spin-off from the Federal University of Minas Gerais and started a partnership with the São Paulo-based Sírio-Libanês Hospital to create an AI Laboratory. Kunumi's machine for groups of ICU patients outperformed the well-known SAPS3 system by 24.4% and evolved into a disease prevention system for individuals. In the Netherlands, Kunumi is mainly active in the logistics sector, developing among others proof-of-concept for an electronic label through the clustering of data that maximizes profit margins.

The Brazilian pharmaceutical industry, a long-time industrial powerhouse, is also adapting quickly to the new AI reality. One of Brazil's largest and most innovative companies, Fleury, even made a strategical change from promoting itself as a pharmaceutical company to a digital company. Fleury started a partnership with IBM Watson to diagnose genetic modifications at an early stage, which will help doctors to identify if a disease is caused by a malfunctioning gene. This project is part of the experimental phase of Watson for Genetics, which will be implemented worldwide.

Dutch SMEs are also becoming more interested in the Brazilian market for applying AI solutions. Through a DHI-subsidy of the Netherlands Enterprise Agency (RVO.nl), Dutch company dPI is able to implement its Reflex platform of Clinical Intelligence in 10 Brazilian hospitals. The dPI platform processes medical data into charts that automatically show trends and alerts where and when intervention is required.

Agriculture

Brazil's huge agricultural sector has attracted a lot of attention from tech companies in recent years, both nationally and internationally. A good example is the subfield of precision agriculture, using ground-based and space-based sensor and imaging technology. Machine learning and AI play an increasingly important role in this digital form of agriculture. Several companies are developing technologies for this new market, such as IBM, Microsoft and Taranis, and Monsanto. This year, Monsanto's Climate Corporation launched the Climate Fieldview platform in Brazil, using deep learning technology, after two years of piloting on 380,000 hectares.

And IBM's research department in Brazil, the first outside the US, is currently developing digital agriculture applications using the Watson platform. IBM is setting up partnerships with several Brazilian universities to further develop Watson, through joint calls for R&D projects with the São Paulo State science foundation FAPESP. In 2017, the second joint call was launched, adding USD 250,000 on digital agriculture to the USD 500,000 of the first call in which University of São Paulo plays a prominent role. One of the applications is the analysis of crop images (from satellites, drones et cetera) for crop control, pest control and automated phenotyping. Other applications include high-resolution weather predictions and knowledge extraction from reference publications on agriculture, using chat bots. The agricultural sector also pushes advances in autonomous transport. Last year Volvo presented an autonomous truck, developed in Brazil, for the sugar cane industry. The truck autonomously tracks harvesters collecting sugar cane. Volvo estimates commercial production could be viable in three years.

Taiwan

By *The Holland Innovation Network, Taipei*

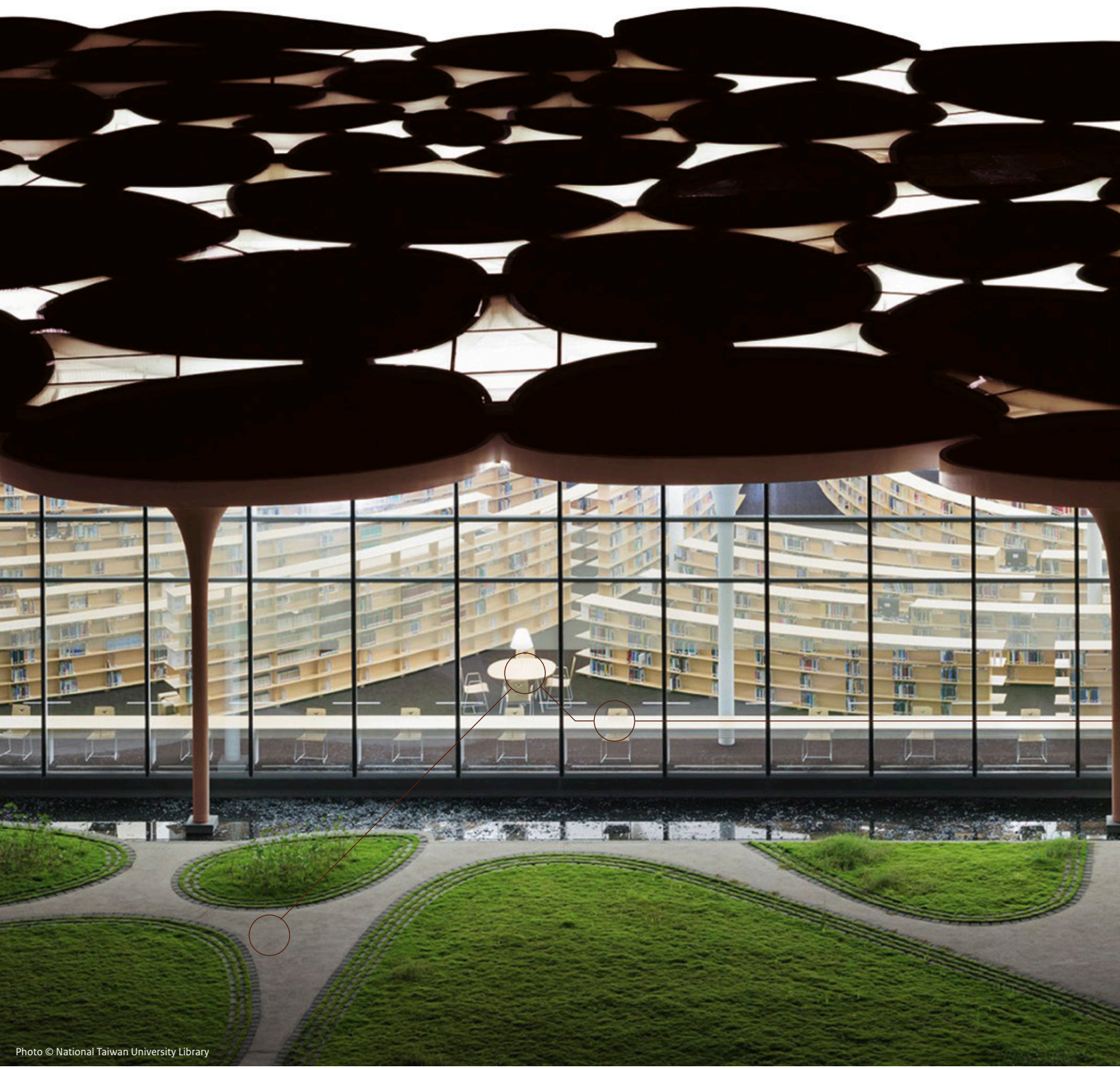
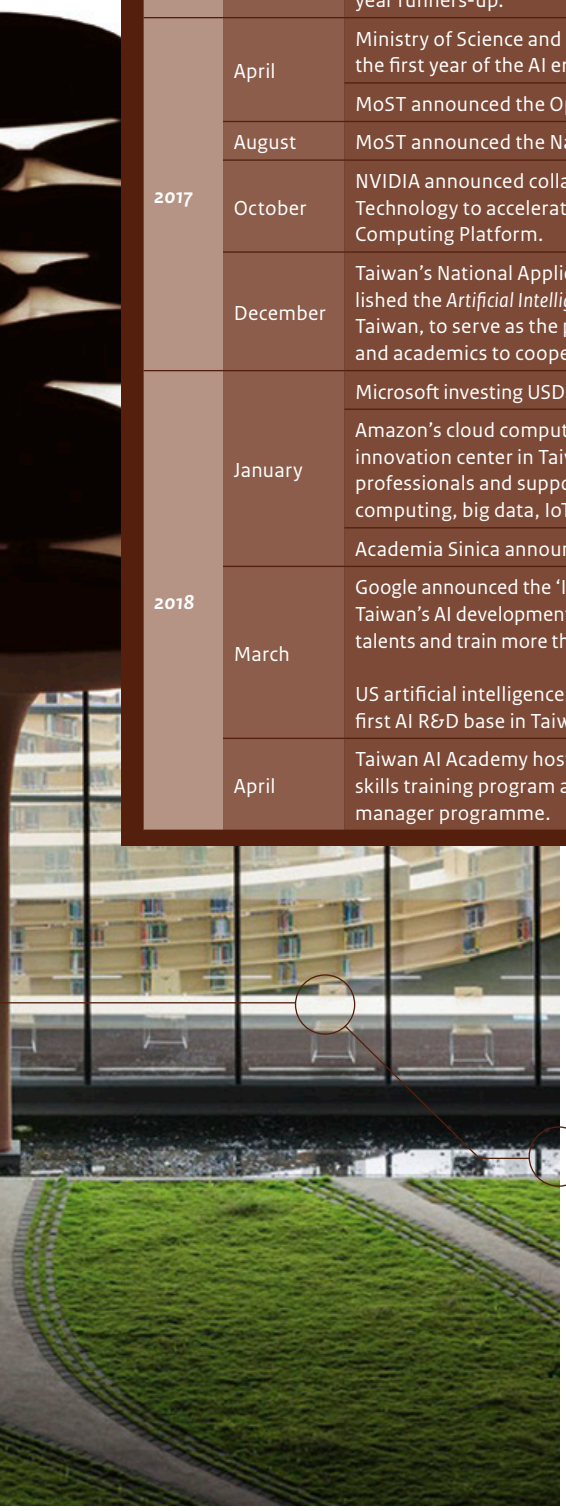


Photo © National Taiwan University Library

Significant events stimulating AI development in Taiwan

Year	Month	Event/ Incidents
2016	March	AlphaGO beat world's top GO player Lee Sedol in a five-game match, the first time a computer GO programme has beaten a 9-dan professional without handicap.
	September	NVIDIA announced collaboration with National Taiwan University to establish the Artificial Intelligence Lab.
	December	Alpha GO was chosen by Science as one of the Breakthroughs of the year runners-up.
2017	April	Ministry of Science and Technology (MoST) proclaimed the year 2017 as the first year of the AI era in Taiwan.
		MoST announced the Opening of the Taiwan AI Lab
	August	MoST announced the National AI Strategy
	October	NVIDIA announced collaboration with Taiwan's Ministry of Science and Technology to accelerate Taiwan's AI Revolution with NVIDIA's AI Computing Platform.
	December	Taiwan's National Applied Research Laboratories (NARLabs) established the *Artificial Intelligence Industry and Academia Alliance* in Southern Taiwan, to serve as the platform for businesses, government officials and academics to cooperate in the development of a local AI industry.
2018	January	Microsoft investing USD 33 million to create an AI (R&D) hub in Taiwan.
		Amazon's cloud computing arm AWS launched their first flagship joint innovation center in Taiwan, where they will provide assistance to tech professionals and supports to high-tech startups in the fields of cloud computing, big data, IoT, and AI.
		Academia Sinica announced the opening of Taiwan AI Academy.
	March	Google announced the 'Intelligent Taiwan project', a large investment in Taiwan's AI development, to hire at least 300 AI engineers, cultivate 5,000 talents and train more than 50,000 digital marketing personnel in 2018. US artificial intelligence company Insilico Medicine establishes Asia's first AI R&D base in Taiwan.
	April	Taiwan AI Academy hosts first graduation with 210 students from the skills training program and 320 students from the weekend business manager programme.



In late 2016, the continuous victories of Google AlphaGO against the worlds' top GO players caught worldwide attention as it was the first time a computer program has beaten a 9 dan GO player without handicap.

Taiwan's semiconductor industry drives AI sector development

The incident also brought unexpected attention to Taiwan's AI talent pool, as the lead programmer, dr. Aja Huang, who also placed the stones on behalf of AlphaGo in the tournament, was born, raised and educated in Taiwan. In the 2016 Asia University Ranking, the National Taiwan University was ranked number 1 in artificial intelligence, with many students offered employment by major AI firms around the world even before their graduation.

AI as industry's X-factor

With the island's unique industrial strengths in ICT, semiconductor and manufacturing as well as a well-recognized human capital pool, the Taiwan government, particularly the Ministry of Science and Technology (MoST), have identified AI as the X-factor to stimulate industrial development.

Focus themes

Semiconductor industry

The semiconductor industry is at the heart of the development of AI applications. AI chips are used in data centers to train systems to analyze and find patterns in volumes of compiled data. That is why semiconductor companies are racing to develop AI chips that could reduce deep-learning cycle times.

Home to two of the world's largest semiconductor companies – Taiwan Semiconductor Manufacturing Company (TSMC) and United Microelectronics Corporation (UMC) – Taiwan holds the world-leading status in the supply chain of semiconductors. The industry accounts for 28% of Taiwan's export in 2016, the AI chip boom is regarded as a golden opportunity to grow export.

Edge AI

AI computing power located at the edge of a network rather than centralized in a data-center is called Edge AI. Many believe the best opportunities matching Taiwan's strengths lie on the edge rather than in the cloud. Autonomous driving, smart home appliances, smart surveillance cameras, smartphones,

robotics, drones, and IoT devices are fundamental to some of the many use cases where it can be essential to run AI algorithms at the edge to avoid latency in receiving and processing data from centralized sources.

Since the endpoint devices require very specific AI-chips utilizing low-power consumption technologies, tech companies are still exploring concepts and developing technologies that will bring AI closer to the edge – this is where Taiwan's competitive advantage lies.

Surveillance cameras and sensors

Video surveillance cameras and sensors are used, for example, in factories or retail environments to gather data that can be analyzed by means of AI to extract valuable insights. Taiwan already has many outstanding optical lens companies such as Largan Precision, which is a supplier of camera lens modules for smartphones, tablet computers, and digital cameras, among other devices. Such companies can benefit from the growth in demand for AI-capable surveillance solutions.

Unmanned transportation and robotics

Hardware manufacturing will still play an important role in the AI era. The demand for components and parts for robotics and unmanned vehicles are expected to rise in the near future. Smart manufacturing systems and equipment is also an area Taiwan could tap into. For example, Foxconn, Apple's main supplier and the world's largest contract electronics manufacturer, is already bringing AI to its factories. Industrial robots, built almost entirely in-house, are already deployed in the company's smartphone assembly lines. It is believed that when AI and automation become prevalent, the robotics hardware sector can benefit the most.

Major programmes

The National AI Strategy: big strategy for a small nation

The government announced the budget of NT$ 16 billion (USD 528.7 million) for 2017-2021 to develop an AI innovation ecosystem in Taiwan in August 2017. The table National AI Strategy provides a breakdown of the various subprogrammes.

National AI Strategy

	Programme name	*Focus*	*Time*	*Budget (NT$)*
1	AI platform	Develop and establish the hardware to provide R&D services	2017-2020	5 billion
2	AI innovative research center	Talent training and creating added value in the following areas: Core technology Bio-medical applications Smart Device applications Smart Manufacturing applications	2017-2021	5 billion
3	AI robot maker spaces	Test field for AI in robotics	2017-2021	2 billion
4	semiconductor 'moonshot' programme	to explore ambitious and ground-breaking smart technologies	2018-2021	4 billion
5	Formosa Grand Challenge competitions	to engage young people in the development of AI applications	2018-2021	100 million/ year

Major Players

NVIDIA

- Established AI lab with National Taiwan University (Sep 2016).
- Collaboration with MoST to develop AI Computing Platform (Oct 2017)
  - Building Taiwan's first AI-focused supercomputer powered by NVIDIA® DGX™ AI computing platforms and Volta architecture-based GPUs.
  - MoST and NVIDIA's Deep Learning Institute will train 3,000 developers over the next four years on the use of deep learning in smart manufacturing, the Internet of Things, smart cities and healthcare.
  - NVIDIA to help MoST to establish a Youth Technology Innovation and Entrepre-

Semiconductor Moonshot Programme

The MoST launched the ambitious NT$4 billion (USD 132 million), four-year project to assist Taiwan's semiconductor industry in developing cutting-edge process technologies and foster talents specializing in artificial intelligence.

The initiative encompasses cognitive computing and AI processor chips; next-generation memory designs; process technologies and materials for key components of sensing devices; unmanned vehicles and augmented and virtual reality applications; and Internet of Things systems and security.

It also involves promoting academic-private sector collaboration in producing more talents versed in semiconductor process technologies, material development and integrated circuit design.

Project Moonshot draws on Taiwan's world-leading technological prowess and will slingshot it to the head of the international pack in the race to develop the latest AI applications. The timing is also opportune as local firms must be ready for fresh challenges in 2022, when global high-tech heavyweights are likely to launch commercial production of chips made with the advanced 3-nanometer technology node.

The initiative has the backing of local powerhouses such as Advanced Semiconductor Engineering Inc., MediaTek Inc., Phison Electronics Corp. and Taiwan Semiconductor Manufacturing Co. Ltd.

neurship Base for local AI startups through NVIDIA's Inception programme.
- NVIDIA will support MoST's overseas talent training programme for post-doctorates by offering high-level internship programs.
- NVIDIA will provide NVIDIA Deep Learning Accelerator (NVDLA) technology for IoT and SoC devices, plus technical support, to MoST's Project Moon Shot, AI Edge

Taiwan AI Lab

Taiwan AI Laboratory is a privately funded research organization which aims to integrate AI expertise and resources from academic, public and private sectors. The organization is headed by Ethan Tu, a former senior researcher at Microsoft, who is well-known in Taiwan for creating the PTT bulletin board service which has grown into one of Taiwan's most influential online forums since its launch in 1995.

Microsoft AI Research Centre

Microsoft has announced plans for an AI hub in Taiwan, pledging to invest 1 billion New Taiwan dollars (USD 33.7 million) over two years in an effort authorities hope will help advance a shift in the local tech sector. Assembling a research and development team of more than 200 over five years, the center will aim to devise new applications for the technology and new businesses based on it. Microsoft intends to tap into Taiwan's highly skilled pool of professionals.

The research center will work in areas such as voice recognition and anticipating the desires of search engine users to suggest answers quickly. It will work to simultaneously bring more industries into AI and vice versa.

The center will also cooperate with Taiwanese authorities, who hope AI will further transform Taiwan's high-tech sector to become less hardware manufacturing dependent.

Amazon's joint Innovation Centre with New Taipei City (Jan 2018)

Amazon Web Services (AWS), a cloud computing subsidiary of Amazon.com Inc., signed a memorandum of understanding with the New Taipei City government in Jan 2018 to set up a joint innovation center in the city.

AWS will invest intellectual rather than financial capital in the center, which will help New Taipei City and Taiwan as a whole to better connect with the rest of the world. In addition, AWS will provide training and technical assistance to small and medium-sized enterprises in Taiwan, leading them to upgrade their technology, and will help schools to cultivate talent. One of the aims is to develop at least 15 innovative teams a year.

Microsoft will invest over USD 33 million in a Taiwanese AI hub

Artificial Intelligence Industry and Academia Alliance

Established by the National Applied Research Laboratories (NARLabs) under MoST, the AI Industry and Academia Alliance focuses on promoting innovation technology and industrial application in AI. The core activities include:

- Serve as communication platform for AI-related governmental departments, knowledge institutes and industry to facilitate AI cooperation
- Integrating available resources for to stimulate development of the AI industry and establishment of the AI Industrial Ecosystem.

The alliance focuses on development of AI applications in the areas of Smart Mobility, Smart biotechnology, Smart Machinery and core technologies including big data analysis, deep learning, image recognition and algorithm development.

Taiwan AI Academy

Among the problems that the Taiwan AI Academy hopes to address is the flight of talented individuals from Taiwan to other countries, and the mismatch between talent cultivation and application.

Rather than a basic training course, the intention of the AI Academy is to attract people who are already specialists in their field, and by connecting to the academy, develop innovative strategies that can be adopted across fields of business, and education.

The Taiwan AI Academy acts as a platform for exchange and cooperation across various tech fields, as well as between academia, government and business. It aims to take a crucial role in bringing new vitality to Taiwan's development at the start of the fourth industrial revolution. The Taiwan AI Academy had its first graduation of 210 students from the skills training programme and 320 students from the business manager programme. Local business, including MediaTek, AU Optronics Corp, Inventec Application Corp, Chunghua Telecom Co and Cathay Financial Holdings Co were waiting to recruit talent outside the conference hall where the graduation ceremony took place.

Insilico Medicine

Insilico Medicine announced the establishment of its first AI R&D base in Taiwan. It will form an Alliance with the Center for Biotechnology, the Institute for Information Industry, and TUL Corporation to implement

SWOT analysis of Taiwan's Strength in AI by local government thinktank

Strengths (S)	*Weaknesses (W)*
• Strong core technology research capacity in academic institutes • Strength in areas of Visual recognition and Machine Learning • Strong foundation in visual recognition system with many companies invested in the area • Complete IC supply chain provides good foundation for the development of AI Chips • Good understanding of the data and applications for manufacturing • Advantage in agriculture and textile industries	• Application service providers own data but lack technological advantages • Online service providers are too small to collect sufficient data and this creates difficulties for model training • Generally, local industries lack knowledge on AI • IC manufacturers just started developing AI, they require external technology cooperation to accelerate the R&D process
Opportunities (O)	***Threats (T)***
• High demand in market application (financial, healthcare, retail, manufacturing) • There are many existing external resources to accelerate the development of AI applications • High computing demand for deep learning application, increasing demand for terminal hardware	• Global large international companies are active in AI, raising the entry level • Fierce competition between new AI startups • The mainland controls big data in the Chinese language dominating Chinese language natural language processing

A few startups are leading the way in Taiwan AI

the 'AI Digital Health Talent Development Project' in order to accelerate the integration of cross-domain talent.

Rising stars

So far, the most exciting developments in Taiwan's AI field have not come from large tech firms or the government. Instead, a few startups are leading the way.

Appier

Appier aims to provide AI platforms to help enterprises solve their challenging business problems. This year, the company has been named in CB Insights' 100 Companies 2018 for the second time (www.cbinsights.com).
It serves roughly 1,000 global customers and has offices in 12 countries across Asia. In August 2017, Appier announced it had received a Series C investment of USD 33 million from a consortium including Japan's SoftBank and Line, Korea's Naver, Singapore's EDBI, and Hong Kong's AMTD Group. Appier has now received overall investment of US$82 million.

Umbo Computer Vision

Umbo Computer Vision (CV) was founded in 2014 as an artificial intelligence company that makes autonomous video security systems for businesses by applying AI technology in surveillance cameras, a segment where Taiwan has long been competitive. The technology can reduce false alarms by as much as 20 times. The company has received a combined US$10 million investments and sold their systems in the United States and some to Fortune 500 corporate clients.

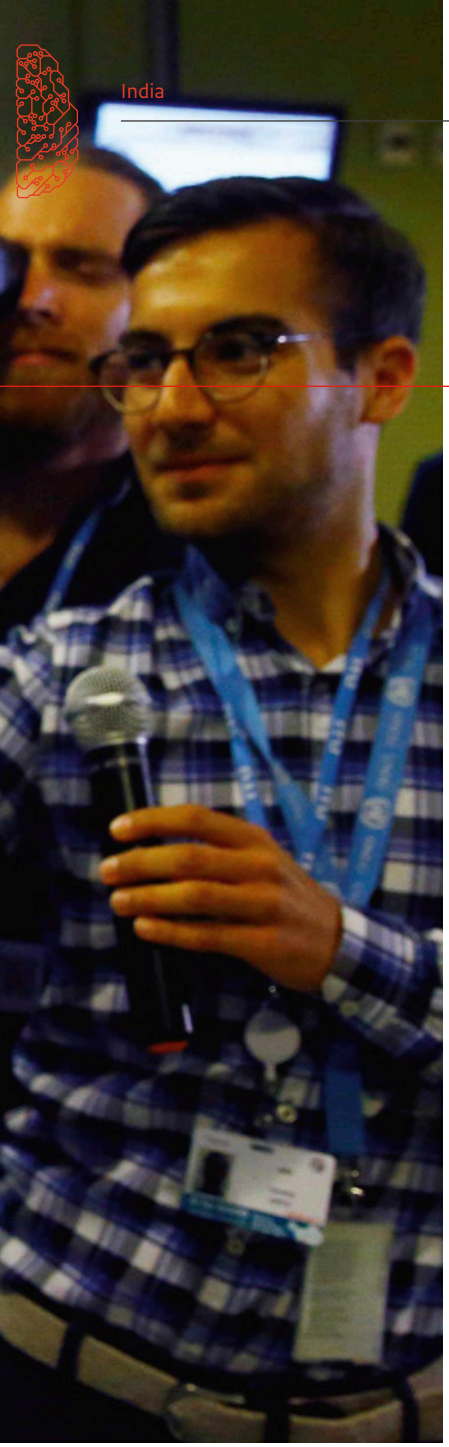
DT42

DT42 is a deep-learning startup that aims to eliminate the barrier between AI research in lab and real application and to bring AI to real life, so as to make AI easier and more affordable for businesses to deploy to edge devices.
The company combined experiences in computer vision, deep learning and embedded systems to make AI running locally on devices, so devices can understand videos and images well. This solution can be installed on embedded systems for deep learning inference to recognize people, faces and actions (such as violent motion).

Niche Player India

By Martijn Lammers, *Holland Innovation Network, Mumbai*

Although India does not yet match AI leaders Silicon Valley and China, nearly 300 startups are using some form of AI, according to startup tracker, Tracxn. Some of these Indian startups might be interesting partners for AI development. This could be in specific niches such as Natural Language Processing. Key players and the Indian government are investing in AI, but not at the level seen in some other countries.



Healthcare is seeing the most profound applications of AI with many forms of diagnoses being automated

While some of the world's major tech companies such as Google, Microsoft, Facebook, Amazon and IBM have taken the lead in developing AI-enabled products, there is a lot of scope for the development of breakthrough technologies for startups. Many of these big companies – Microsoft, IBM, Amazon, Accenture and the Dutch oil major Shell – have their research centers in India and carry out research work in a wide number of areas in AI.

When it comes to the academic sphere, most of the research work in this field is carried out at some of the leading institutes in India such as Indian Institute of Science (IISc) and Indian Institutes of Technology (IIT's) in Delhi, Mumbai, Kanpur, Kharagpur and Chennai.

Industry is also funding a major part of research work at these institutes, for example Robert Bosch Engineering and Business Solutions (RBEI) signed an MoU with the IIT-Chennai recently to set up the Robert Bosch Centre for Data Science and Artificial Intelligence (RBC-DSAI). The centre will undertake fundamental research in many areas of AI and data science - deep learning, reinforcement learning, network analytics, interpretable machine learning, and domain-aware AI.

Areas influenced by AI

Advances in AI and machine learning are finding applications in different fields from supply chain optimization to media where more and more news content is becoming AI-driven. In the finance sector, machine learning is intelligently predicting credit card risks for new applicants, and insurance claim is being assessed by machine learning agents.

Microsoft's research centres in US and India (Bengaluru) are busy developing a new class of machine-learning software and tools to embed AI onto bread crumb size computer processors. The researchers imagine all sorts of intelligent devices that could be created, from smart soil- moisture sensors deployed for precision irrigation on remote farms to brain implants that warn users of impending seizures so that they can get to a safe place and call a caregiver.

Healthcare is seeing the most profound applications of AI with many forms of diagnoses being automated. This in turn is reducing overheads and errors, extending treatment to undeserved population.

The government of India state Telangana has an agreement with Microsoft India to adopt cloud-based analytics for *Rashtriya Bal Swasthya Karyakram*, its healthcare screening program for children. The state has agreed to adopt Microsoft Intelligent Network for Eyecare (MINE), which is an AI platform to reduce avoidable blindness. Microsoft India, in collaboration with L V Prasad Eye Institute, launched MINE in December 2016. MINE is a global consortium of eyecare providers, research and academic institutions joining hands to apply AI to help in the elimination

of avoidable blindness and scale delivery of eyecare services worldwide. The consortium is working on diverse datasets of patients across geographies to come up with machine learning predictive models for vision impairment and eye diseases.

AI in India at policy level

AI-powered applications and services have become widely available to Indian consumers because of the global digital economy. Indian academics, public researchers, labs, and entrepreneurs face a different challenge than the corporations that dominate the space, however, as the infrastructure necessary for an AI revolution in India has not been a priority for policymakers. Government support in AI research and development is essential to its advancement, evident in the levels of government engagement in the US and China.

It is only recently that cloud infrastructure providers have made efforts to invest in this technology in India: Microsoft has pledged to invest in three data centers for its Azure cloud infrastructure. While these investments are positive signs for the country, it will need more time and serious attention from the government for India to become an important player on the global map when it comes to AI. In June 2018, NITI Aayog, India's main government thinktank, released a discussion paper on the national strategy for Artificial Intelligence (www.niti.gov.in).

Five **startups**

Arya.ai, Mumbai

Investment: an undisclosed amount from YourNest Angel Fund and VentureNursery.

The team: Vinay Kumar Sankarapu, chief executive officer, and Deekshith Marla, chief technology officer.

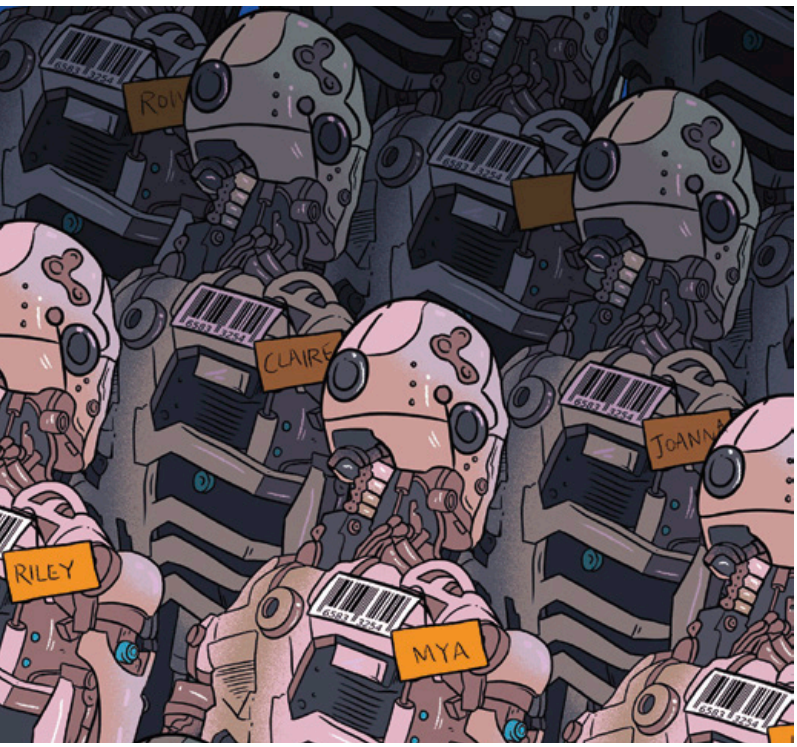
Intelligence factor: many startups are working with AI to solve problems in banking and insurance. Arya.ai tells them how to. Many startups in India are working with deep learning, which aims to make human effort minimal. Arya.ai works as an enabler. For instance, if a consultancy firm is building AI for its investment banking client, Arya.ai will provide the firm with the tools to build it, creating the neural network – a vast computing system that mimics the human brain; it will create a cloud system which will allow the AI to evolve, learn from its earlier tasks and apply them to the next one.

Locus.sh (Mara Labs INC.), Bengaluru and US

Investment: at least USD 2.75 million from Exfinity Venture Partners, Blume Ventures, BeeNext and others.

The team: Nishith Rastogi, who has worked with Amazon and eBay; and Geet Garg, who was with Amazon. The two had co-founded PinChat, a location-based conversational platform, in August 2014.

Intelligence factor: Locus has developed route-planning algorithms so companies can chart the best possible route to deliver an order and allow a salesperson to cover the maximum number of points in the shortest time possible. Locus aims to automate all the human decisions involved in sending a package. With clients such as Hindustan Unilever, Quikr, Urban Ladder and Lenskart it has a lot on its hands.



More time and serious attention from the government of India is needed for the country to become an important global player in AI

Tricog Health Services PVT. LTD, Bengaluru

Investment: USD 2 million from Inventus Capital Partners, Blume Ventures and angel investors.

The team: Charit Bhograj, a cardiologist; Zainul Charbiwala, who worked at IBM India and Qualcomm; Udayan Dasgupta, who worked at Texas Instruments; and Abhinav Gujjar, who worked at Thomson Reuters and Microsoft.

Intelligence factor: what can take up to six hours before treatment starts, Tricog accomplishes in a few minutes. Nearly 7.5 million people die every year of heart disease. Around 1.5-3 million of them are in India; half of them can be saved by early diagnosis. ECG – a heart health test – is conducted through a machine which records the heart's electrical movement. These machines are not widely available in India, nor are there enough cardiologists to interpret ECG data. And it can take up to six hours before a patient is diagnosed and sent for treatment, says Bh ograj. So Tricog set out to help doctors make instant diagnoses of heart attacks and ensure treatment is not delayed.

Netradyne, Bengaluru and San Diego, US

Investment: raised USD 16 million from Reliance Industries Ltd in June 2016.

The team: founded by Avneesh Agrawal, a former Qualcomm Inc. president for India and South Asia, and David Julian, a former principal engineer at the US-based chip-maker.

Intelligence factor: Netradyne's Driveri, a powerful camera that analyses driving patterns and can help determine the cause of an accident. The soap-bar-sized device is attached to a vehicle's rear-view mirror and rests on the inside of the windscreen, pointing towards the road.

Embibe, Bengaluru

Investment: USD 9 million from venture capital investors such as Kalaari Capital and Lightbox.

The team: founded by Aditi Avasthi, a former Tata Consultancy Services (TCS) and Barclays executive.

Intelligence factor: in a country where the overall quality of education consistently lags behind those in developed nations, Embibe's core AI product can be a game changer. Its learning platform is being used by thousands of students and the startup is in talks with educational training centres. Embibe, which runs a website and a mobile app, collects data from students, charging only for advanced analysis and personalized learning recommendations. Students can actually improve test scores by fixing basic mistakes using its AI platform.

Japan seeks cooperation

At the CES electronics show in Las Vegas, Sony made a big announcement. The company is set to design image sensors for automotive giants Toyota and Nissan. Japan's automotive sector is in the middle of a transition towards CASE (Connected, Autonomous, Shared and Electric) cars. Artificial Intelligence (AI) is an integral part of this transition. Japanese companies seek (international) cooperation, especially across sectors.

By Mihoko Ishii, *Holland Innovation Network, Tokyo*

In high-tech Japan, AI and the Internet of Things (IoT) are seen as key technologies for sustainable economic growth. Japan has been at it for a long time, with regard to collecting and providing access to public data.

The term 'big data', therefore, is not very 'hot', let alone controversial. Big data is an integral part of Japanese business. Thanks to the fast development of AI and IoT technologies, large industrial sectors such as automotive, electronics and robotics are very active in the use of existing high-quality data. Today, Japan's greatest challenges are building a platform, standardization, privacy and cyber security. Optimal cooperation between government and industry is crucial. Another challenge is the lack of human resources. This provides an opportunity for highly-educated Dutch knowledge workers.

Industry

Japanese industry is extremely technology-driven. 80% of annual national R&D investments of about € 150 billion comes from the private sector. Japanese industry regards AI as one of the most important technologies for the ecosystem. Nikkei Asian Review predicted that

annual private sector investment in 2017 would grow to close to € 1 billion, a 5.7% increase over 2016. Of the 268 companies investing in these technologies, the large actors in automotive (Toyota, Nissan, Honda, Suzuki, Mazda, Denso), electronics (Fujitsu, NEC, Toshiba, Panasonic) and robotics (Mitsubishi Electric, FANUC, Yaskawa) are active in AI with various initiatives.

In 2017, Toyota decided to invest € 80 million extra in the AI venture capital firm Preferred Networks (PFN). Honda set a new record for itself in 2017, by investing € 57 million in AI R&D, a 9.4% increase over 2016.

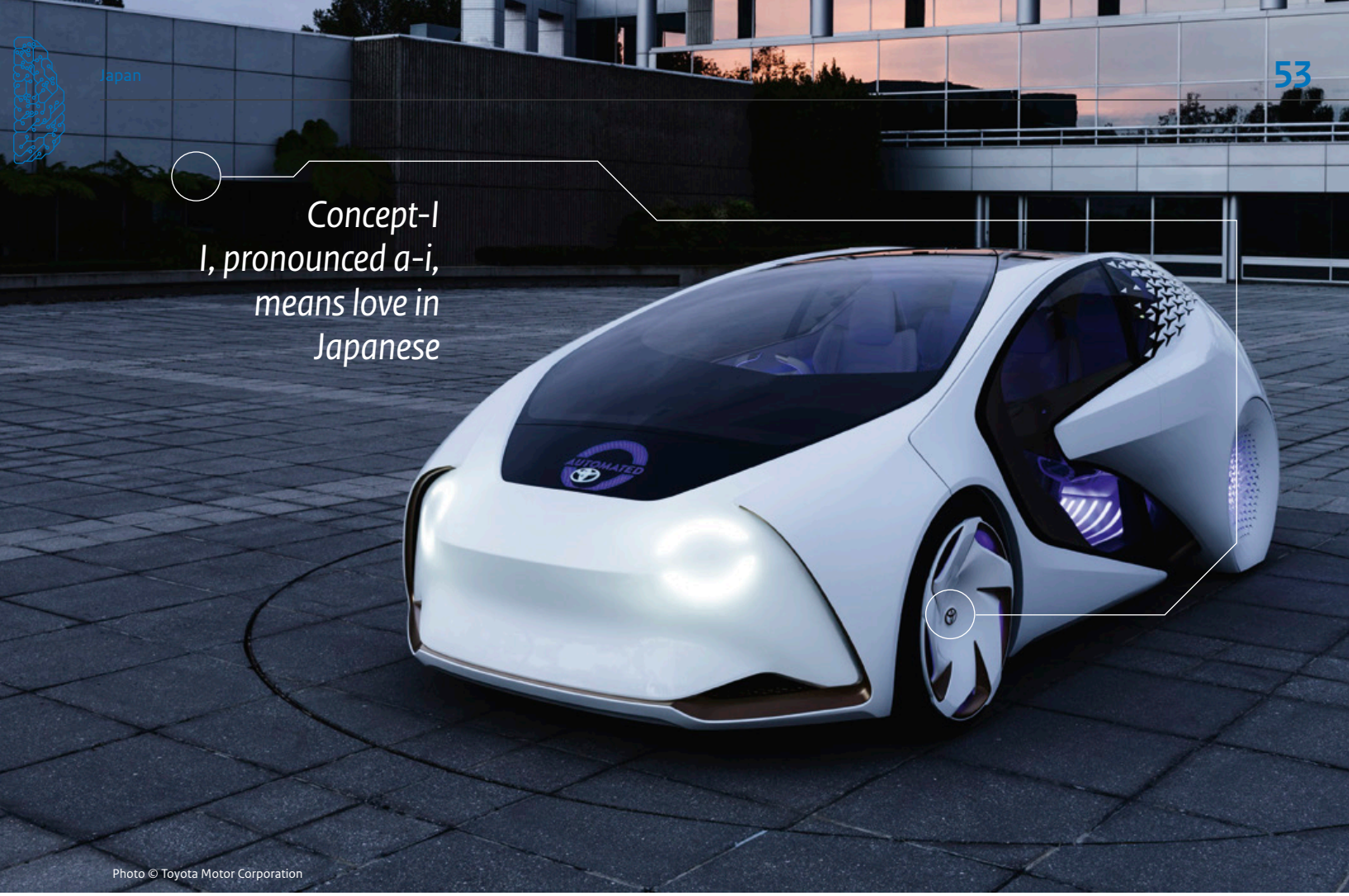


Photo © Toyota Motor Corporation

Mitsubishi Electric set aside € 16 million, a growth of 5.3%. Panasonic has decided to focus on AI camera and robot technologies. It will continue to recruit AI engineers and in five years' time hopes to create a turnover of several hundred million euros, having 1,000 engineers.

Some examples of projects:

Automotive

Toyota, Nissan and Honda have invested heavily in the development of autonomously driving cars.

Toyota recently unveiled the new concept car model 'Concept-I'. 'I', pronounced a-i, means love in Japanese. The company strives for a situation wherein driver and car really are in love, i.e. understand each other without words.

Subsidiary company the Toyota Research Institute (TRI) conducts research on the combination of deep learning (applying learning functions to a network) and existing AI technologies. CES 2018 had a TRI cockpit model with the latest deep-learning technologies (facial, behavioural and speech recognition) detecting a driver's emotions. March 2018 will probably have seen the launch of the Toyota Research Institute-Advanced Development (TRI-AD) in Tokyo where, led by an ex-Google robotics specialist, researchers from Toyota, Aishin Seiki and Denso combine their expertise. The professional language there is English. That way, TRI-AD hopes to attract even more talent.

Honda is also developing its AI concept model NeuV. The company uses Softbank's 'emotion engine'. Honda aims for a car which is not only able to understand what the tastes or emotions of the driver are, but also wants the AI function itself to communicate. The company works on an autonomously driving car with Waymo and sees AI as a fundamental part of further development. Since the end of 2017 Honda also cooperates with Chinese AI business SenseTime, specialized in deep learning and image recognition.

Nissan has adopted a slightly different approach. It uses Seamless Autonomous Mobility (SAM). Normally, AI assists the driver to arrive at a self-driving car. Nissan thinks the other way around. With SAM – which has NASA robot technology VERVE as its core – Nissan want AI to assist people in difficult situations. Nissan has in-house operators who give instructions to AI in

Japan does not see robots as a threat

emergency situations. These are stored in the cloud and distributed to other self-driving cars.

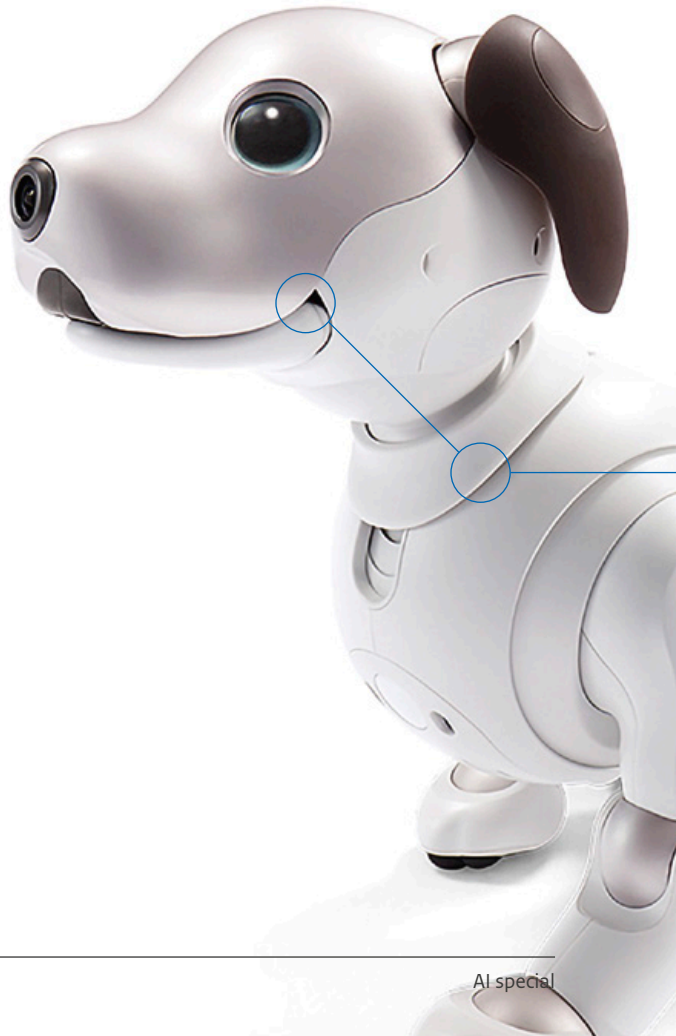
In addition to the regular financial R&D means there is also a new structure. Recently Nissan, Renault and Mitsubishi Motors decided to collectively invest € 7.6 million in AI over the next five years. This funding is allocated via Alliance Ventures to entrepreneurs in new mobility (electric transport, self-driving, connected and AI).

Electronics

Large electronics companies Fujitsu, NEC and Toshiba have also taken up AI and decided to work on deep-learning algorithms. Each of the three companies will second dozens of employees to the RIKEN Centre for Advanced Intelligence Projects and will set aside several € million for this five-year cooperation. Omron is starting a new AI research institute on factory automation and healthcare.

Fujitsu is a very active ICT company with great knowledge of big data and systems. It has concentrated its AI efforts under the icon 'Human-Centric AI Zinrai'. Zinrai brings together AI technologies such as detection, recognition, processing, decision-making and support, deep learning and machine learning. Over thirty years in the making, the Zinrai Platform Service has already carried out more than 300 business projects, among which a cooperation with a Spanish hospital. The HIKARI Advanced Clinical Research Information System using Zinrai assists in choosing the right medication for patients.

In addition to applications for healthcare, in the next few years Fujitsu expects to work on AI systems for communication devices, robots and cars. At the end of 2017, Fujitsu has initiated a cooperation with Microsoft on systems. A combination of Microsoft 365 and Fujitsu expertise will bring about a new platform for the new way of working.
Last year NEC, which is active in big data and security, concentrated its AI technologies under the flag of 'NEC the WISE'. The company is leading in speech recognition, image and video recognition, language and semantic understanding, machine learning, prediction and detection, and optimal planning and control. Combining these technologies can strongly contribute to a safe and sustainable living environment. NEC's police fingerprint systems are known worldwide and facial recognition of the Japanese immigration service at airports is also provided. The NEC Analytics Platform allows for horizontal data sharing within an organization, NEC's so-called 'data lake'.



Robotics

Around the world, robotics is seen as a possible threat to human employment. Japan sees things somewhat differently. The country has an immense societal challenge in human resources due to its ageing and decreasing population. According to research by Accenture Japan will have a labour shortage of 11 million jobs by 2030.

Therefore, in Japan robots which could replace humans as part of the labour force are seen as very positive development. Of course, the balance between what robots should do and what humans should do is crucial. Large robotics firms such as Mitsubishi Electric, FANUC and Yaskawa Electric are revolutionizing factory automation.

Mitsubishi Electric (MELCO) recently started the icon Maisart (Mitsubishi Electric's AI creates the State-of-the-ART in technology). Under its aegis existing deep-learning, reinforcement-learning and big data analysis technology is used for new developments in AI.

Fanuc, which specializes in industrial robots and factory automation, will invest in the company Intelligent Edge System (IES), together with Hitachi and AI startup Preferred Networks. Using deep learning, IES will develop a fast, real-time control system for industrial robots and machines linked to the network.

Government and science

Under supervision of the Cabinet Secretariat's highest official, the so-called government Chief Information Officer (CIO), the Japanese government supports AI initiatives. Super Smart Society or Society 5.0 is central to Japan's current science and innovation agenda until 2020. Society 5.0 aims for greater synergy among different societal systems. AI is seen as a vital tool to achieve this, next to big data and cyber security.

Recently the Strategic Council for AI Technology (SCAIT) started its work. The ministries of Information and Communication, Education and Economic Affairs have joined hands to work out a strategic approach.

NICT Centre for Information and Neural Networks (CiNet), RIKEN Center for Advanced Intelligence Project (AIP) and AIST Artificial Intelligence Research Center (AIRC) are the three national institutes for AI research. Additional research funds are available through JST and NEDO.

Opportunities for the Netherlands

Japan has much in-house experience, basic technologies and financial means for the rapid development of AI. However, the Japanese feel they are lagging behind the US. According to Dr. Yutaka Matsuo of Tokyo University this is a result of a shortage in AI personnel. There are not enough data scientists or software developers to process the volume of high-quality learning data. Even the automotive sector working on self-driving cars has to recruit AI researchers from abroad. Matsuo also sees Japanese corporate culture with few opportunities for young people as disadvantageous. For AI development the flexibility and creativity of the younger generation is paramount. Matsuo regards deep learning as a breakthrough for Japanese AI.

In view of the AI situation in Japan, knowledge export, research cooperation and acquisition offer the greatest opportunities for the Netherlands. Well-known Japanese bottlenecks are: distance, language / culture barrier, Japanese competitors, and specifically the long term which is needed to get a cooperation going successfully.

Russia: startup potential is a hidden AI gem

In Artificial Intelligence (AI), Russia is following global trends. AI and neuro technology are considered key to the development of Russia's digital economy. Standards are expected to be in place by 2020.

By Pauline Döll, *Holland Innovation Network, Moscow*

Final responsibility for AI has not yet been assigned to one single ministry. The government and science sector are dominant, with the private sector picking up slowly. Business opportunities arise from fast-growing e-commerce, the low awareness of data protection, large cities having a 24/7 economy as well as smart city priorities, and deregulation needs.

Policy framework

Since its introduction in July 2017, the main policy framework for digitization – including Artificial Intelligence – is the programme 'Digital Economy of the Russian Federation'. It defines the goals, objectives, directions and terms of implementation of the state policy's main measures.

The government organizations responsible for implementation (tasks between brackets) are:

- Ministry of Communication and Mass Media (formation of research competencies and technological reserves, information infrastructure, and information security);
- Ministry of Economic Development (normative regulation, personnel and education);
- Government Analytical Center (project office for implementation);
- Skolkovo Foundation / Innovation Center (center of competence for regulatory framework).

In 2018, close to € 40 million was allocated to implement the programme, mainly to the Ministry of Communication and Mass Media. After installation of the new government in May 2018, it was announced that this ministry would become the Ministry of Digital Development, Communications and Mass Media.

In 2014, the National Technology Initiative was launched to stimulate the development of nine high-tech topsectors in the Russian Federation, aiming to ensure that Russia will be a leading producer of such technologies in 2035. Sectors concerned are: AutoNet, AeroNet, EnergyNet, FinNet, FoodNet, HealthNet, MariNet, NeuroNet, and SafeNet. They all include AI technologies. Road maps for each sector define intermediate steps on the way to 2035. R&D and innovation project calls are launched regularly. Target group: Russian companies, universities and scientific bodies.

Therefore, it will probably take a leading role concerning the Russian digital economy.

Past developments (2007-2017)

Over the past ten years in Russia 1400 scientific projects on AI were carried out, about 85 per cent of them not-for-profit. The development of AI was mostly driven by the Russian state and state(-owned) businesses, with 6,000-10,000 active researchers. Around € 311 million was spent on AI R & D during this period.

Public AI-related funding was primarily targeted at the public sector, transport, defense and security. Projects mostly concerned the development of data analysis, decision support systems and image and video recognition.

In Russia the private sector is only slowly picking up on artificial intelligence and machine-learning trends and developments. Universities and scientific institutes produce a large portion of AI-related research and technologies.

T-adviser, the forum of the largest IT companies in Russia, on the growth potential of the Russian AI market:

- Artificial intelligence and machine-learning market grows to € 380 million by 2020 (from only € 9,5 million in 2017);
- Market share of AI in Russian industry will comprise € 330 million by 2021;
- In five years' time, 80% of all decisions in the financial domain will be taken by means of AI;
- Within three years, 50% of the consumer sector will make use of bots for consumer services.

Examples of AI in Russia

As a result of past projects and developments, AI applications are found in different areas:

- personalized services (telecom);
- increased efficiency by data analysis in retail and industry (telecom, home appliances, oil well drilling, banking);
- automatizing and optimizing technical support and communication by bots (food retail, telecom);
- assistance and advice on products (air tickets retail);
- human resources and personnel recruitment;
- processing and analyzing texts and documentation;
- quality control during manufacturing processes (pharmaceutical industry);
- face recognition for advertisement targeting.

In Russia the private sector is only slowly picking up on artificial intelligence and machine-learning trends and developments

Igor Drozdov, Chairman of the Board of the Skolkovo Foundation: "AI is in a somewhat more distant future than crypto-currencies and ICO (primary placement of cryptocurrencies). That is why we decided it is too early to regulate it right now. At the moment, it is necessary to determine our attitude to AI, its scope and the legal status of robots."

A top 5 to give an impression of the state of AI application in Russia:

1. Yandex: in 2017 launched a voice assistant Alice, as an alternative to solutions by Apple (Siri), Google (Google Assistant) and Amazon (Alexa). This system can search for information and personify data, is able to process incomplete instructions and improvise.

2. Sberbank: in 2017 launched a system called iPavlov that can perform risk assessments, do cross-selling, and communicates (with callcenter).

3. Russian startup Stafory provides a service, robot Vera, for hiring new specialists. Vera is able to search for new candidates, make phone and video calls, make appointments and provide a list of potential candidates within in short timeframes. Vera is used in many Russian companies and is entering the US market.

4. Moscow Government has developed a digital strategy 'Smart City 2030'. A 12-year project with AI applications to make life and work in Moscow more comfortable and safe. Key aspect will be personalized access to digital services, based on the personal characteristics of each citizen.

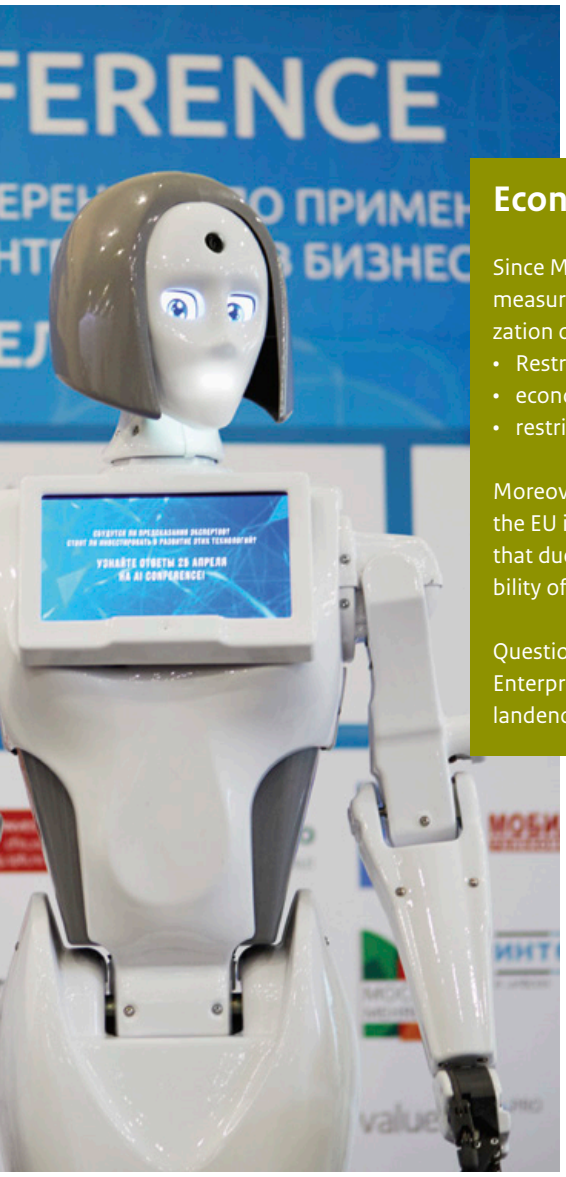
5. Prisma is a Russian startup able to style users' photos according to the works of famous artists using an artificial neural network.

Other Russian companies active in AI are: ABBYY, Detectum, MTS, Megafon, Magnit, N-Tech.Lab, Rostelecom, Semantic-Hub, Telegram and Visionlabs.

Talent pool

Russia has a massive potential in qualified specialists for AI projects. Across the country, 286 universities operate relevant MSc programmes. Annually Russian higher education institutes train about 50,000 students in 65 specialties related to data analysis, machine learning, speech and image recognition, computer linguistics, and similar topics.

Natalia Parmenova, Executive Director of SAP CIS: "SAP plans to build a strategy for the development of software solutions using artificial intelligence for business, in partnership with Russian researchers and in the interests of Russian customers in the field of industrial production, fuel and energy, service business and the public sector. As a first step, the Department for Big Data Management was opened in the Moscow office of SAP CIS; this will also deal with projects in the field of artificial intelligence."



Economic sanctions Russian Federation

Since March 2014, the EU has progressively imposed restrictive measures against Russia. The measures were adopted in response to the illegal annexation of Crimea and the deliberate destabilization of Ukraine. The measures concern, among others:

- Restrictions of economic relations with Crimea and Sevastopol;
- economic sanctions;
- restrictions on economic co-operation.

Moreover, the EU adopted a list of physical and legal entities and private persons whose capital in the EU is frozen and whose entry to the EU is restricted. Companies should pay attention to the fact that due diligence regarding partners and activities in the Russian Federation remains the responsibility of the company.

Questions related to these sanctions can be addressed to Ondernemersloket of the Netherlands Enterprise Agency (RVO.nl) at: https://www.rvo.nl/onderwerpen/internationaal-ondernemen/landenoverzicht/rusland/ondernemersloket-sancties-rusland.

At the moment, in Russia artificial intelligence is still a non-regulated technology

Relevant academic and scientific organizations are:

- Higher School of Economics (Moscow)
- Innopolis University (Tatarstan)
- ITMO University (St. Peterburg)
- Moscow Institute for Physics and Technology (IT-Technopark Phystechpark)
- Moscow State University
- Novosibirsk State University
- Plekhanov Russian University of Economics (Moscow)
- Skoltech Institute for Science and Technology (Moscow)
- St. Petersburg State University
- Tomsk State Polytechnic University
- Sectoral institutes under the Academy of Sciences, such as the Institute of Image Processing Systems; Moscow Institute for Automobiles
- Scientific Research Center Applied Semiotics (Tatarstan)
- Ural State Federal University (Ekaterinburg)

Startups

As a logical consequence of the large AI talent pool in Russia, many startups are active in AI. A study by Science Guide (2017, *http://sci-guide.com/landscape.pdf*) of the AI market and key industry players shows that startups using artificial intelligence technologies occupy 16% of the market. The largest part of startups is specialized in machine vision (33%), followed by natural language processing, text analysis (14%), chatbots (9%) and speech recognition (5%). Least represented in the market are recommender systems technology (8%), predictive analytics (7%) and robot technology (7%). An overview of 50 promising Russian startups in the field of AI can be found via *www.vc.ru/24386-50-ai-companies* as well as via Rusbase *www.rb.ru/ai/*.

Regulatory steps

At the moment, in Russia artificial intelligence is still a non-regulated technology. First steps to create a regulatory framework are foreseen by the end of 2018. The aim of the government is to develop national standards, increase cooperation with foreign countries, and contribute to the development of international standards. An important milestone date is March 2020, when the federal government will review progress on national standards (cloud, fog, quantum technologies, virtual and augmented reality systems, and AI technologies). By June 2020, national standards for information security in systems that implement these technologies should be in place.

AI Key Technology for Smart Industry Turkey

The Turkish government has defined priorities for its national innovation policy. One of these is increasing the export share of high-tech products. Applied research and development in AI has been recognized as one of the possible drivers.

By Rory Nuijens, *Holland Innovation Network, Istanbul*

Turkey focuses on applied research as well as the valorization of research. So-called techno parks are being implemented, including technology transfer offices and cluster organizations. Cooperation between industry and knowledge institutions is also being stimulated.

Turkey has a well-developed manufacturing industry in automotive, household appliances, electronics, and machine construction. Developing Smart Industry applications for these sectors has been set as a priority. At the start of 2017, then-Minister for Science, Industry and Technology, Mr Isik, stated that "in order to realize perfection in critical and key technologies Turkey has to intensify R&D spending". He specifically mentioned the areas of smart industry, cyber-physical systems, artificial intelligence, sensors, robotics, the Internet of Things (IoT), big data, cyber security and cloud computing.

Argos AI

Argos AI is a startup ofn Middle ast Technical University (METU) which detects foreign objects on airport runways through image analysis. Air authorities can be warned in time of any dangerous situation. Together with the Turkish air organization a demonstration project is being prepared at Sabiha Gökçen airport. The company has also been awarded a Horizon 2020 SME Instrument phase 1 subsidy.
See https://www.argosai.com/home

There is focus on AI, a wide range of possible applications in manufacturing, but there is little national coordination

This recommendation was put forward in the national ICT strategy 2017-2019. The Turkish government links AI to Industry 4.0-related developments. There is no specific AI policy: it is seen as an enabling technology and has been integrated as such in the recently-founded Robotics Cluster at the TUBITAK Marmara research centre.

Defining actors

Research institutions

Bogazici University

Turkey's most prominent AI researcher, Professor Levent Akin, is the founding father of two research laboratories at Bogazici University: the Artificial Intelligence Lab and the Perceptual Intelligence Lab. The first one is chiefly involved with robot-human interaction, multi-agent systems and bioinformatics. The second specializes in visual and image processing as well as machine learning. Professor Akin has stated he will also focus on AI's ethical aspects in the near future.

Sabanci University

The Cognitive Robotics Lab of Sabanci University has four focus areas:

1. 'Cobots' and scenario development for robot-human cooperation in factories;
2. Service robots;
3. Multi-agent systems for autonomous driving. (Interface with the Smart Mobility Cluster of TUBITAK Marmara Research Centre);
4. Medical robots for rehabilitation.

See box on Interact Technologies.

Istanbul Technical University

Istanbul Technical University has a research centre for AI and robotics. It focuses on developing autonomous mobile robots, robot-sensor systems and deep learning.

AI at other universities

Other Turkish knowledge institutions with activities in AI and robotics are Özyeğin University, Bilkent University and Middle East Technical University. They focus on such areas as machine learning, image analysis, cobots, swarm robots and autonomous robots which could be used in case of a natural disaster.

Interface with industry

Various talks with representatives from unversities and companies present the following picture. Firstly, the interface with Turkish industry is relatively weak. Much of university research is applied research; however, it remains unclear how and to what degree this research finds its way to the market. Secondly, there is no adequate national coordination of research. In order to answer these challenges TUBITAK's Marmara Research Centre now has a robotics cluster which links knowledge institutions, business and government.

The Turkish government

The main actors on the government side include the Ministry of Science, Technology and Innovation. It decides on research policy strategy and has defined Industry 4.0 as an important theme for the Turkish economy. Recently, it presented its report on the future of the Turkish ICT industry.

One of the main projects on ICT in Turkey is called IT Valley of Turkey, supported and funded by the Ministry of Science, Industry and Technology. A remarkable plan is to establish an Industry 4.0 Transformation Center to house the main Industry 4.0 transformation activities for both government bodies and industrial partners. With this center, supported by planned robotics and IA labs with more than 3 million m² campus area, The Valley is a prominent candidate for a leading role in Turkey's future AI and Industry 4.0 action plans.

TUBITAK disburses research grants and much of the Ministry's strategy takes the form of specific project call-based subsidies. Several programmes focus on fundamental research, some of them also seeking cooperation with industry and SMEs. Local authorities, specifically in the Marmara region around Istanbul, are also involved. This region is home to large automotive and household appliances factories, for whom the development of smart factories is crucial.

Business

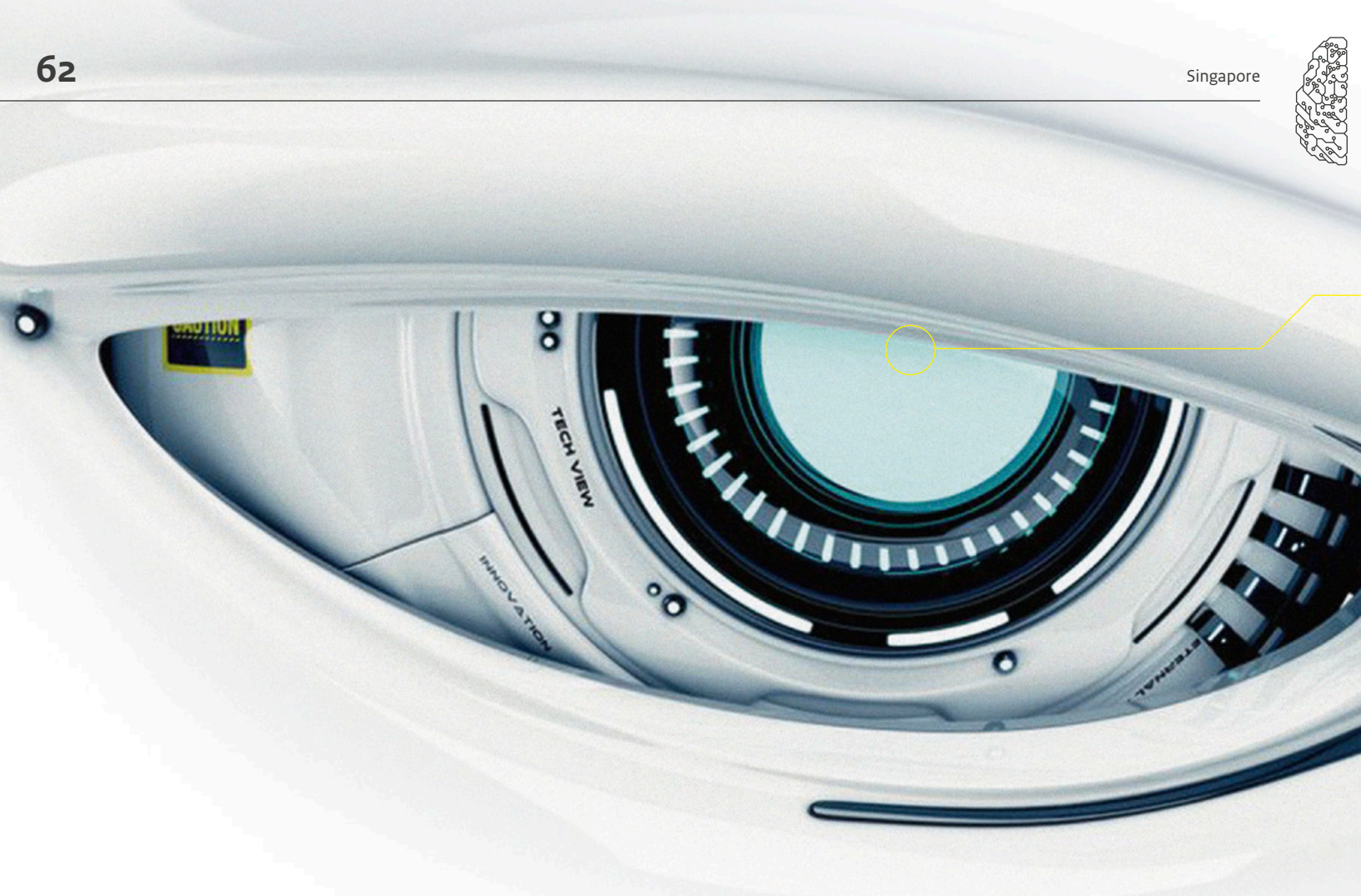
Companies which apply AI can be divided into categories. A number of companies is active in industrial automation, for example Altinay (www.altinay.com). It supplies production lines to the automotive, household appliances and glass industries. The second category consists of startups focused on internet services (for example: chatbots), united in the TRAI platform (www.turkiye.ai). A third group is made up of high-tech startups, often university spin-offs such as the ones mentioned in the boxes accompanying this article.

In conclusion

There is focus on AI in Turkey, within government, university education and research, and Turkish business. There is a wide range of applications possible in the Turkish manufacturing industry. National coordination, however, is still at a very early stage. There is also little or no attention given to AI's ethical dimension.

Interact Technologies

Two researchers of the Sabanci University's Cognitive Robotics Lab have launched a spin-off for developing 'rehabilitation robots' for patients recovering from a heart attack. Using AI, treatment plans are optimized and doctors are advised with regard to continued treatment. See http://interact-technologies.com/



Smart Nation Singapore

By the Holland Innovation Network, *Singapore*

Singapore is striving to become a smart nation, a leading economy powered by digital innovation. The push for digitization is one of the strategic thrusts within Singapore's Prime Minister Office. Singapore struggles with a rapidly ageing population, which puts a lot of pressure on the workforce. Digitization is seen a solution for the country to improve efficiency, productivity and quality of life.

Artificial Intelligence (AI) is one of four frontier technologies within the Smart Nation initiative. Singapore needs top ideas and talent in high-performance computing (HPC) and artificial intelligence (AI) to turn its vision of a Smart Nation into a reality, said Senior Minister of State for Communications and Information and Education, Janil Puthucheary.

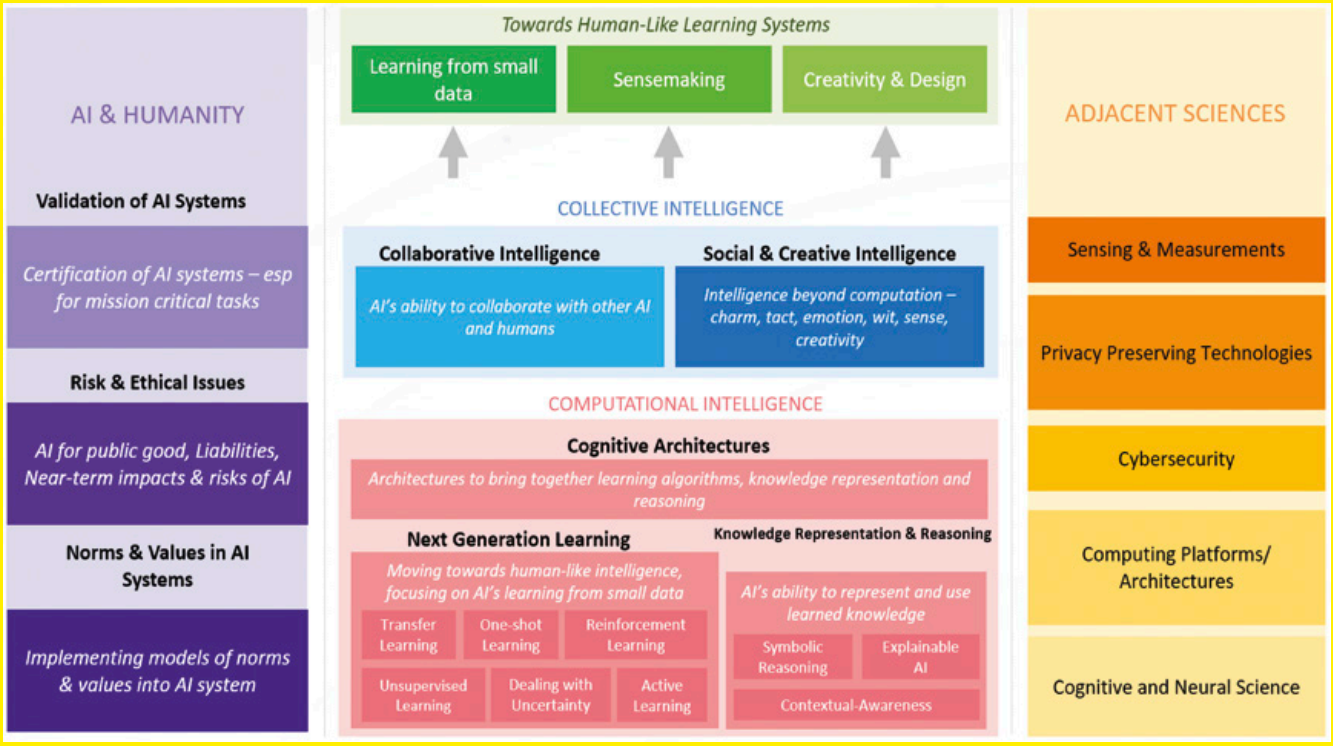
One goal is broadening the application of AI in the private sector and realize 100 successful projects

National programme on AI

In 2017 the national programme on artificial intelligence AI.SG was introduced to boost Singapore's AI capabilities, build an AI ecosystem and put Singapore on the AI world map. This government-driven programme brings together all Singapore-based research institutions, AI startups and companies to grow knowledge, tools and talent. AI.SG is administered by the National Research Foundation (NRF), in cooperation with other government bodies such as the Smart Nation and Digital Government Office (SNDGO) the Economic Development Board (EDB) and SG Innovate (a government firm nurturing deep-tech startups). The NRF is investing close to € 95 million over the next five years.

AI research focus areas in Singapore

(source: AI.SG)



City management	*Healthcare & wellness*	*Finance*
• Transport planning & optimization • Infrastructure management • Safety & security • Productivity improvement	• Healthcare analyses • Personalised medicine • Disease pattern prediction • Community care • Smart homes	• Risk modelling & prediction • Fraud detection • Productivity improvement • Digital personal financial advisor for elderly

Four key AI programmes

1. **Fundamental research.** Investing in the next wave of scientific innovation to realize genuine breakthroughs. The first grant call was in the field of advanced research in machine learning, computer vision and natural language processing, and how AI interacts and collaborates with humans. The next grant call will be launched in 2019.

2. **Utilizing AI for major societal challenges.** AI.SG will define a series of Grand Challenges that can be effectively addressed using AI. Examples of ideas are a smart traffic light control system and a personal digital advisor for the ageing population.

3. **Broadening the application and use of AI in the private sector.** The goal is to realize 100 meaningful projects and proof-of-concepts. AI.SG matches problem statements of enterprises and AI researchers and will also provide up to $ 250,000 worth of co-funding. The projects will develop solutions that are not yet available and have to be realised within a timeframe of 9-18 months. Current examples of experiments include predictive maintenance of lifts and voice-to-text recognition.

4. **AI Apprenticeship programme** to increase the pool of talent. This company-led training programme is for recent graduates (less than three years ago) and addresses the current lack of AI engineers and data scientists in Singapore.

The government actively supports the private sector to adopt AI for optimization and productivity improvement. Companies with 30% Singapore shareholders or more can apply for financial support by AI.SG. Singapore welcomes international cooperation, particularly in fundamental research. The national AI programme supports this, when based on cooperation with a researcher from one of the Singapore universities or A*STAR, the national institute for applied research.

Leading role for government

Technologies such as AI are crucial to meet the challenges to Singapore's future: ageing, lack of natural resources, shortage of low- and medium-skilled workers. Research reveals that AI could propel Singapore's annual economic growth rate from 3.2% to 5.4% and increase labour productivity by 41% by 2035 (Accenture, 2017).

The government collects a great amount of data in public space, using sensors, cameras and gps. Rules and regulations concerning privacy are less strict and mainly apply to the private sector. The people of Singapore perceive the government as trustworthy, providing security and stability. These conditions facilitate the collection of data and implementation of AI. Cyber security is an important theme in Singapore, because of the dependency on IT in the digitization strategy.

The government of Singapore has successfully adopted the idea of regulatory sandboxes to allow financial institutions and FinTech startups to test their innovations (amongst others AI-based advisory solutions.) This sandbox approach will also be applied to other sectors and technology domains (e.g. health tech). The sandbox creates a safe space to experiment and allows companies to take risks with new services, without fear of regulatory backlash.

Rapid growth in R&D initiatives

AI R&D investment and initiatives in Singapore have grown NTU and Chinese technology giant Alibaba announced a joint research institute focusing on AI – the first of its kind outside China. It will combine 'human-centered' AI expertise of NTU (health, ageing and home and communities) and technologies of Alibaba in the fields of natural language processing (NLP), computer vision, machine learning and cloud computing. The research lab will aim to improve healthcare and city planning and starts with a combined total of 50 researchers from both organizations.

January 2018, NUS' new AI centre has started operations. This NUS Artificial Intelligence Innovation and Commercialisation Centre (NUSAIICC) is a cooperation between NUS and the Suzhou Industrial Park Administrative Committee, and is located in the NUS Research Institute in Suzhou, China. NUSAIICC focuses on joint R&D and is a platform for the commercialization of AI in the fields of smart cities, healthcare and fintech. The AI centre supports startups and companies with AI knowledge, its application, its acceptance and marketing new technology.

Singtel, NTU and NRF Singapore have established a corporate lab to accelerate AI and data science innovation. At the Singtel Cognitive and Artificial Intelligence Lab for Enterprises (SCALE@NTU) 100 researchers will be active. Another 200 research engineers, graduates and undergraduates will be trained. The lab will develop applications in the areas of public safety, smart urban solutions, transportation, healthcare and manufacturing.

Initiatives in finance, health and city management

The financial sector is the second largest industry in Singapore. Implementing e-payments is a priority within the Smart Nation initiative. Several companies and startups are competing for the tender to develop a uniform platform for e-payments. The system will make use of QR codes to facilitate transactions. Simultaneously, the Data Science & Artificial Intelligence Research

Singapore particularly welcomes international cooperation in fundamental research

Centre (DSAIR) of Nanyang Technological University (NTU) is working to improve existing payment systems and develop new ones, in cooperation with, among others, PayPal. Next to this, the Monetary Authority of Singapore (MAS) is working with key industry stakeholders to develop a guide to promote the responsible and ethical use of AI and data analytics by financial institutions.

Singapore's increasing aging population, high inflation of medical costs and shortage of doctors and nurses make AI in healthcare a priority within AI.SG. SG Innovate supports two startups using computer vision and AI to help doctors improve the accuracy of disease diagnosis. The first being development of 'the stethoscope of the future', combining computer vision and AI and deep learning. The second one a solution that can predict the risk of relapse in stroke patients.

Data is one of the main drivers for success in Singapore's Smart Nation. Singapore operates over 1,000 sensors active on and around the island, measuring variables ranging from air quality to security. The biggest obstacle is sharing data between different governmental agencies. There is lack of standardization and a common platform. Therefore, the government aims to develop one platform to gather data from sensors of all government agencies, the Smart Nation Sensor Platform (SNSP). The platform opens up new opportunities for data analytics, artificial intelligence and sensor technologies.

Singapore pushes the development of autonomous vehicles (AV); there are several test beds. Already, autonomous shuttle buses are driving in Nanyang Technological University and driverless taxis are ferrying passengers around the one-north district. These are just a few of Singapore's many efforts to use AI in the transport sector. The government is also working on the introduction of AV in freight transport, and utility operations such as road sweeping.

AI brings huge opportunities for Singapore, however there are also some major challenges in the adoption of the technology. AI talent is scarce and society will need to address the social, ethical and legal issues associated with AI. Some say social adoption might be a bigger challenge than the technology; discomfort about the use of AI in health and autonomous systems is widespread.

AI activities in Singapore as set off against Technology Readiness Levels

(source: AI.SG)

Invest in the Next Wave		***Address National Challenges***				***Increase Industry Adoption***		
TRL1	2	3	4	5	6	7	8	TRL9
AISG NRF Fellowship		AISG National Grand Challenges				AISG's 100 Experiments		
Thematic Fellowship						*100 AI application projects for end users*		
AISG NRF Investigatorship						AISG "Makerspace"		
Thematic Investigatorship						*Shared computing and AI libraries from AISG for industry*		
Fundamental Research		*Challenging statements in Healthcare, Finance and Smart Cities*						
		AI Policy and Governance				Spin-offs - POC/POV Projects		
Curiosity-based Research		*Continuous engagement with stakeholders on policies and regulations*				*Hackathons, Industry Outreach and Networking*		

Netherlands Enterprise Agency

Netherlands Enterprise Agency (RVO.nl) encourages entrepreneurs in sustainable, agrarian, innovative and international business. It helps with grants, finding business partners, know-how and compliance with laws and regulations. The aim is to improve opportunities for entrepreneurs and strengthen their position. Netherlands Enterprise Agency is part of the Ministry of Economic Affairs and Climate Policy and works at the instigation of ministries and the European Union. Some activities of the Commodities Boards are also included. The Agency works in The Netherlands and abroad with governments, knowledge centres, international organisations and countless other partners.

Holland Innovation Netwerk

The Holland Innovation Network or - in Dutch - Innovatie Attaché Netwerk, is a collective of officers working for the internationalisation of Dutch R&D. The IA offices, always part of a Netherlands embassy or consulate, are stationed in France, Germany, Israel, Sweden, UK, Russia, USA (incl. Canada), Brazil, China, India, Japan, Taiwan, Singapore and South Korea.

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