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Artificial intelligence in medicine: assistance for human senses

There is no way around it. Whether we like it or not, artificial intelligence (AI) has long been part of our lives, in traffic management, marketing campaigns or in the fields of medicine and life sciences. AI is omnipresent, often without us being aware of it. Baden-Württemberg is home to one of the largest AI research consortia in Europe and has recently become one of the European hotspots for this key technology.

The idea that computers can develop human-like capabilities at the cognitive level has been around for a long time. For example, back in 1950, the mathematician Alan Turing invented a test that can be used to determine whether computers have a mind that is equivalent to humans. The Turing test involves to find out whether a human can successfully distinguish between a human and a machine in a blind test[1].

For many decades, computers lagged behind the ability of humans, at least until 2017, when the computer passed the Turing test and was shown to be as intelligent as a human. Since then, convincing phone calls can be made or reviews written without them being recognisable as machine-generated. Even in the field of medicine, computers can be used to analyse image data automatically, identify drug candidates or plan personalised treatments.

Artificial intelligence is booming – also in the life sciences

Robots are the stars of the AI boom because they can show many human abilities and can, amongst other things, support us as care robots or domestic helpers, or as tiny assistants in the human body that can carry out medical tasks.

All these capabilities are driven by artificial intelligence (AI), which, with the development of powerful computers and artificial neural networks, as well as large amounts of data collected from the Internet or social media, is already controlling many areas of our lives. In the opinion of many experts AI will, in the future, become even more widespread, and also be increasingly used in the life sciences. AI is considered a key technology of our time, and its opportunities and risks are therefore currently being discussed, including some controversial topics; for example, in the "Artificial Intelligence – Social Responsibility and Economic, Social and Ecological Potential" Study Commission of the German Bundestag or as a theme of the Science Year 2019[2].

The fields of medicine and the life sciences are currently experiencing an AI boom. The reason for this is that we have reached a point at which the abilities of humans alone are no longer able to exploit existing potentials: state-of-the-art technical possibilities in combination with increasing automation in laboratories and clinics as well as the development of high-throughput techniques have, over the last few years, led to a data deluge. The comprehensive analysis of all these data represents an almost impossible challenge for humans, leaving much of the available information untapped.

An MR image, for example, which is routinely taken every day in many medical practices and hospitals, has several thousand shades of grey. However, it is currently necessary to reduce this number to less than a hundred in order to make it possible for physicians to be able to capture and interpret the images. An algorithm that would be able to include all data, i.e. all shades of grey, would perhaps yield completely different results from humans. This also applies to many other imaging data that are produced in medical institutions every day and whose information content is not being used optimally; X-ray and ultrasound images or microscopic images, for example. This situation is likely to change in the future. It is expected that the use of AI will make it possible to use innovative technical developments and the data produced far more efficiently than is currently possible.

Machine learning plays a major role in AI

The term AI (artificial intelligence) generally summarises algorithms with human-like decision structures. A single and precise, universal definition does not yet exist. In general, however, a distinction is being made between weak and strong AI: strong AI assumes that algorithms have the same intellectual abilities as a human mind or even surpass it. The weak variant is designed to solve specific application problems. However, while the developed systems are capable of self-optimisation and are also designed to simulate human thinking, they can only handle very limited tasks. As we are not yet able to develop strong AI, we are currently concentrating on the research and implementation of the weak variant. The German government does so too with its national strategy for artificial intelligence called "AI made in Germany"[3], which, since 2018, has been concentrating on twelve fields of action with the goal of making Germany and Europe a leading AI location.

AI constitutes machine learning and deep learning. Machine learning, i.e. the ability of computers to find a solution to problems without every step being explicitly programmed, just by learning from examples, has become very useful in the life sciences. Of the many AI methods that are nowadays available to experts, deep learning has become particularly popular for deriving patterns and models. Inspired by how the human brain learns, deep learning uses artificial neural networks which, based on huge amounts of data, repeatedly connect what they have learned with new content, thus learning new things.

AI in Germany has several centres

The Apollo robot was developed by the Max Planck Institute for Intelligent Systems in Tübingen and specialises in perceiving and manipulating different objects. The goal is to develop a robot that is able to learn how to grasp objects correctly.

According to experts, Germany is, in comparison with other countries, well positioned with regard to AI research and development. That said, both the German and the European research and development landscapes run the risk of falling behind due to the massive solicitation of researchers by institutions from other countries and by industry.

The situation is somewhat different when it comes to commercial marketing. A study carried out by the consulting company Roland Berger in 2018 found that the USA had already taken the lead in the number of AI start-ups. AI start-ups are regarded as the drivers of innovation for AI technology. According to the Roland Berger study, almost 40 percent of AI start-ups are based in the USA; Europe comes second with 22 percent, but is closely followed by China and Israel[4]. Germany takes eighth place and has just over a hundred AI start-ups. In 2018, the German government launched an "Artificial Intelligence Strategy"[3] aimed at providing support to AI start-ups in order to close the knowledge gap. Although it was originally planned that three billion euros would be invested in AI over the next five years, only a total of 500 million euros will initially be spent to strengthen Germany's AI strategy for 2019.

In Germany, AI start-ups and research institutions are not primarily found in a specific area. Instead, there are several

centres[5], including the German Research Centre for Artificial Intelligence that has branches in several German cities, as well as around 25 universities and institutions of the Fraunhofer and Max Planck societies, that focus on AI.

Baden-Württemberg wants to expand its leading position

Compared to other German states, Baden-Württemberg has a particularly high number of AI centres. As far as academic research is concerned, almost all of Baden-Württemberg's universities are focussed on this field. Several more institutions play an important role in the development and application of AI: the Digital Hub Karlsruhe at the Karlsruhe Institute of Technology (KIT), the BrainLinks-BrainTools cluster of excellence in Freiburg, the Machine Learning cluster of excellence in Tübingen and the Cyber Valley in the Stuttgart-Tübingen region. In addition to the German government's AI strategy, the Baden-Württemberg government has published a strategy paper in which the state sees itself as a future "global leading region of digital transformation" and as a "pioneer of artificial intelligence"[6]. Baden-Württemberg has pledged a two-digit million sum for the "creation of a unique AI ecosystem" and the strategy paper "setting standards for cybersecurity, privacy and ethics". With slightly over 80 AI innovations, Baden-Württemberg already holds a leading position in this field in Germany[7].

Cyber Valley[8], which was established in 2016, is one of Europe's largest AI research centres, making Baden-Württemberg a European AI hotspot. Funded by the Baden-Württemberg government, the Cyber Valley research network consists of the Tübingen and Stuttgart sites of the Max Planck Institute for Intelligent Systems, the University of Tübingen and the University of Stuttgart and seven industry partners: Amazon, the BMW Group, IAV GmbH, Daimler AG, Porsche AG, Robert Bosch GmbH and ZF Friedrichshafen AG. It is expected that several more institutions will join the research network in the coming years. The network covers a broad range of topics, ranging from innovative numerical algorithms designed to make learning machines faster and more reliable, to intelligent systems for self-driving cars and medical analysis procedures.

European hotspot for AI: the Cyber Valley Stuttgart-Tübingen

The MPI for Intelligent Systems in Tübingen has a unique 4D full-body scanner that can scan the body and its movements in space and time in high resolution. This scan is used by the researchers to generate a true-to-life virtual representative of a human being.

"We owe the idea for Cyber Valley to the foresight of Martin Stratmann, President of the Max Planck Society, and the Baden-Württemberg Prime Minister, Winfried Kretschmann. They recognised very early on that AI and robotics are technologies of the future and that only by concentrating research and companies in one area will Germany be able to compete successfully as a future AI location," said Linda Behringer, press officer of Cyber Valley and the Max Planck Institute for Intelligent Systems. "And that's exactly what the Neckar valley has; a number of excellent universities, leading high-tech companies in the immediate vicinity and a broad-based SME sector. Our researchers from Stuttgart and Tübingen publish the greatest number of scientific publications in the field of AI. When it comes to machine learning, Tübingen is among the top 10 locations worldwide."

Cyber Valley aims to advance basic research and to support the training of junior scientists in this area: ten new research groups have recently been set up for this; more will follow in the coming years. A total of ten new AI chairs are currently being set up at the University of Tübingen and the University of Stuttgart. A new graduate school, the International Max Planck Research School for Intelligent Systems, is in charge of the education and supervision of more than 100 doctoral students. With this large number of doctoral students, Cyber Valley is pulling out all the stops to combat the lack of experts in the field.

"Cyber Valley also promotes the start-up culture in the field of science. An ideal environment is being created for start-ups in the Cyber Valley," explains Behringer. "In addition, joint research projects are being planned with the goal of strengthening the technology transfer between the partners. The lively exchange between application-related industrial research and curiosity-driven basic research is expected to benefit both sides and create the ideal breeding ground for spin-offs."

AI is not intended to replace humans

However, as with all innovative new technologies, there are also very controversial views on AI, ranging from "worse than the atomic bomb"[9] or "robocalypse"[10] to "the future market"[11] or "the golden digital age"[10]. However, the different application areas will have to be evaluated and considered separately: while autonomous weapon systems or the consumer-oriented AI of corporations such as Google or Amazon are viewed critically by many people, the acceptance of AI in medical applications is many times greater. Here, most people agree that it is generally desirable to use AI on the broadest possible basis and for the benefit of humans.

AI saves doctors a lot of time and opens up promising new ways of treatment for the patient. It is not about replacing people, but about expanding the possibilities of researchers and therapists, i.e. using machines as assistants for the human senses. In many disciplines, for example in the search for new APIs (active pharmaceutical ingredients) for drugs or as robots that carry out precise operations, computers are already far superior to humans.

Nevertheless, ethicists agree that there must be limits for such applications as well, and that AI systems should only be used if they are understood. They find that it is ok for machines to come up with recommendations, but that the final decisions should be left to humans. In general, the risks of AI need to be examined in detail and weighed very carefully before it is applied. Ethicists also agree that an ethical AI will be have to be worked out with the population and a problem awareness be created, which, for example, also takes into account the handling of one's own data.

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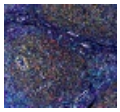

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Further reading:

- Cyber Valley
- Science Year 2019
- National AI Strategy
- Lernende Systeme – Germany's platform for AI