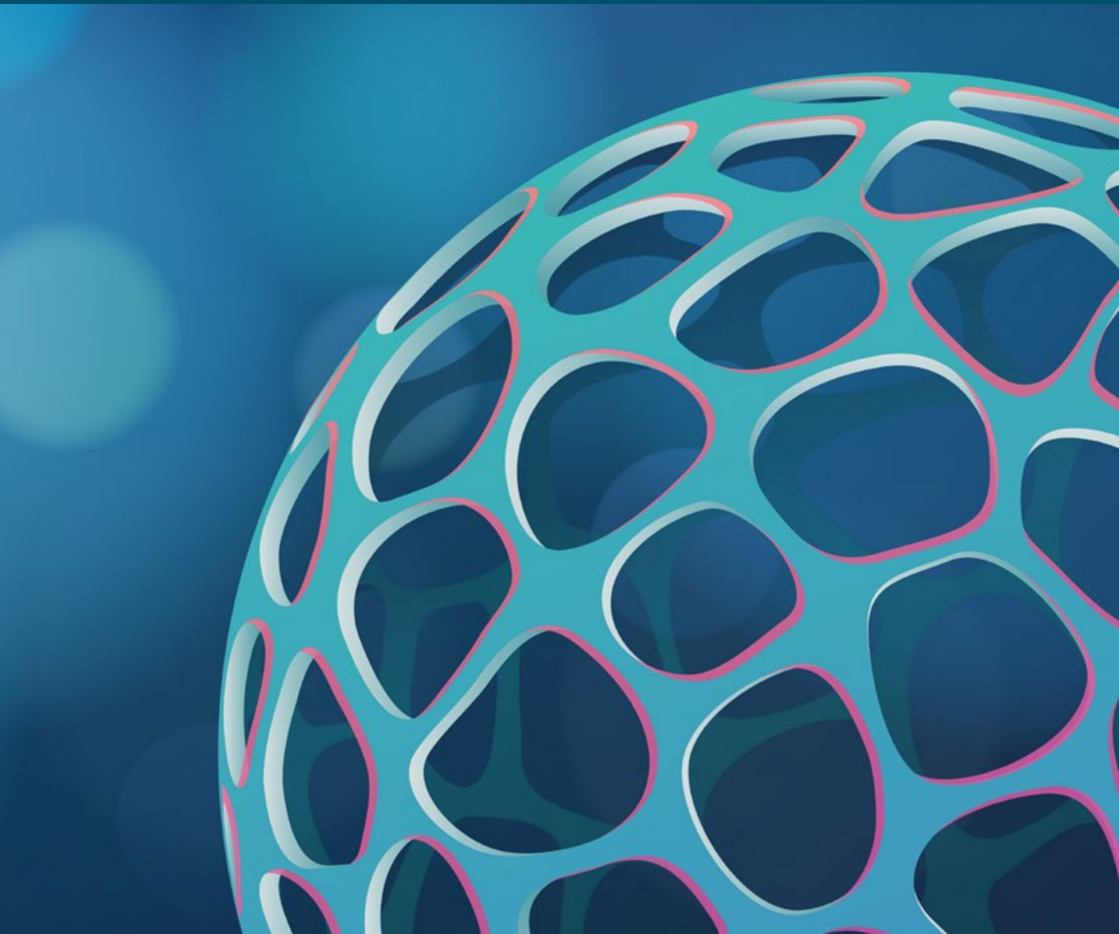
TRENDS IN ARTIFICIAL INTELLIGENCE



CONTENT

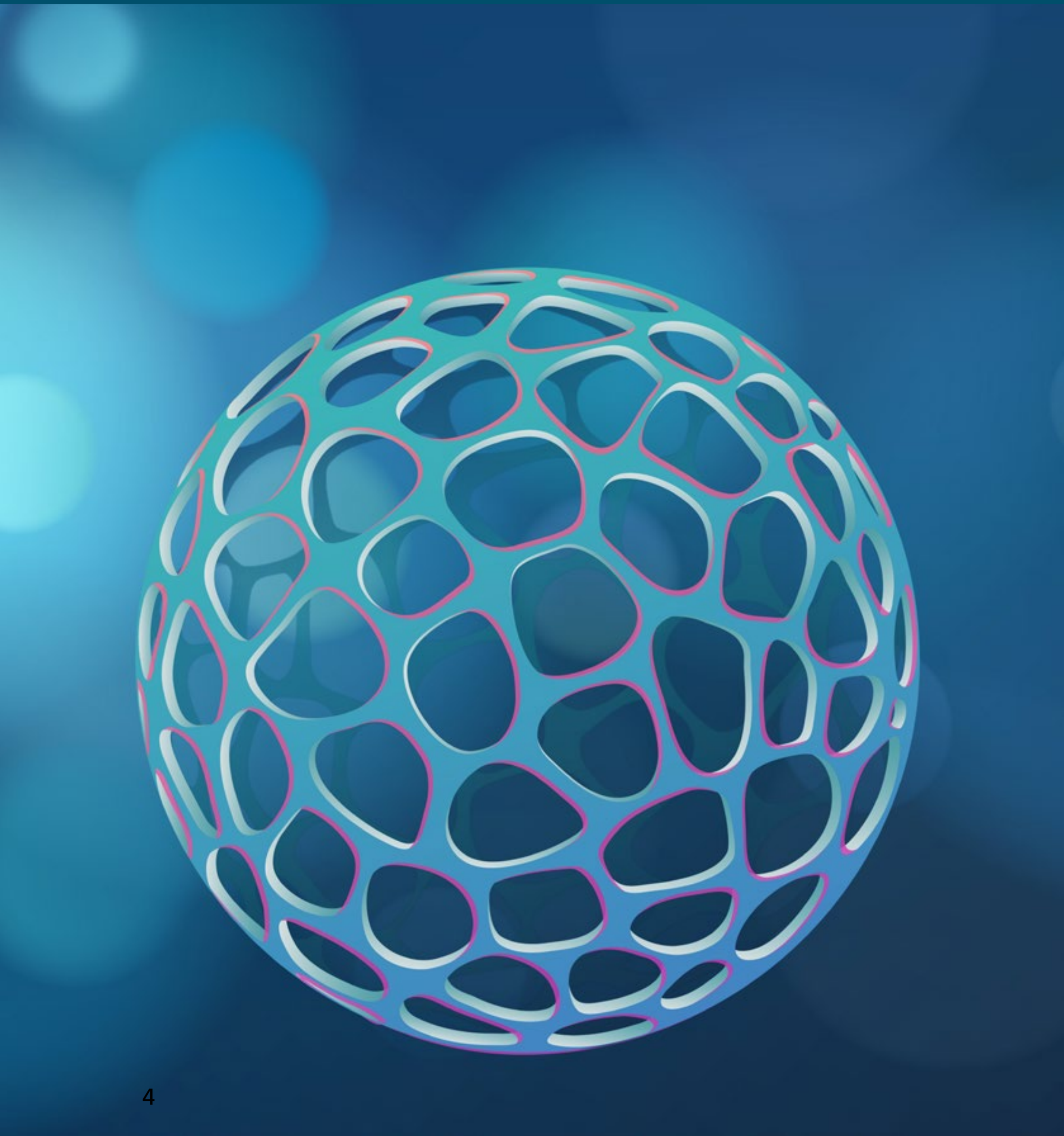
SHAPING THE FUTURE WITH HUMAN AND ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI), cognitive systems and machine learning play a transformative role in bringing about the economy and society of the future. For international business and industrial value chains, this means a fundamental structural change, as these technical systems are capable of learning and are increasingly able to apply what they have learned to new situations. They can plan processes, make forecasts and even interact with people. The International Data Corporation predicts that worldwide expenditure on cognitive solutions will reach 40 billion U.S. dollars by 2020.

However, the use of new technologies not only offers exciting new opportunities: it also constantly presents us with challenges. If Germany is to attain technological leadership in the field of AI, it needs not just technological solutions, but also social dialogue. Fears and myths must be countered with scientific facts. Machines will extend our sphere of influence, but they will not take over and become our leaders.

At many of its institutes, the Fraunhofer-Gesellschaft is developing key AI technologies and applications in such areas as robotics, image and language processing, and process optimization. This includes machine learning techniques for industry, the use of cognitive systems in cyber security and the requisite research into artificial neural networks. Our research makes major contributions to the theory and the ethical design of AI while also being closely aligned with the practical needs of our customers.

Prof. Dr.-Ing. Reimund Neugebauer
President of the Fraunhofer-Gesellschaft



"For 20 years now, we've been hearing regular reports that a breakthrough in artificial intelligence is imminent. But this time it's really true."
Sascha Lobo, author and blogger

"The danger of artificial intelligence does not reside in machines thinking more and more like people, but in people thinking more and more like machines."
Joseph Weizenbaum, computer scientist, cyberneticist and social critic

"Evolution is more than the sum of all revolutions."
Gerald Dunkl, psychologist and aphorist

"While they researched, X-rayed, filmed and radioed, the most delightful discovery revealed itself: the detour is the shortest route between two points."
Erich Kästner, writer

"Artificial intelligence is always preferable to natural stupidity."
Hans Matthöfer, former German federal minister

A brief explanation of key concepts:

Cognitive systems/machines

Cognitive systems/machines are technical systems that capture digital information from sensor data and networks and, based on learning algorithms, derive conclusions, decisions and actions and then verify and optimize these through dialogue with their environment.

Machine learning

Machine learning refers to methods by which an algorithm or a machine, by repeating a task over and over, learns to perform it better and better in relation to a defined quality criterion.

Artificial intelligence

Artificial intelligence (AI) is a branch of computer science that studies how to equip machines with capabilities akin to intelligent human behavior. This can be achieved using preprogrammed rules or through machine learning. Strong AI – also known as artificial general intelligence (AGI) – refers to machines that are able to perform generalizing tasks and are therefore not restricted to a narrow, predefined range of tasks.

Neural networks (deep learning)

Artificial neural networks are a basis for machine learning methods modeled on the network of nerve cells in the brain. They consist of data nodes and weighted connections between them. Machine learning techniques can be implemented by changing various parameters in the network. Deep learning refers to neural networks with a much higher number of levels, enabling new classes of problems to be addressed.

Black-box, gray-box and white-box models

What differentiates black-box, gray-box and white-box models from each other is whether and to what extent the algorithm knows the physical model of the problem to be learned and incorporates it into its learning process. White-box models know the model as exactly as possible. Black-box approaches, in contrast, do not take the model into account at all. Gray-box models use a combination of these two approaches.

Neuromorphic chips

Neuromorphic chips are microchips in which the architecture and properties of nerve cells are modeled at the hardware level. These neuron-like components simulate the brain’s powers of learning and association, which can accelerate particularly the recognition of patterns in pictures or in big data structures.

"WE'RE FAR FROM THE END OF THIS PROGRESS"

An interview with Prof. Dr. Stefan Wrobel, Director of the Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS and Professor of Computer Science at the University of Bonn, about opportunities, challenges and the acceptance of artificial intelligence.

What exactly is artificial intelligence?

Wrobel: Intelligence is a key attribute of human beings – one we tend to credit humans with possessing uniquely. Now, if machines are able to do things that we would generally classify as intelligent, we call this artificial intelligence. The term currently encompasses machines that are able, for instance, to interpret images or respond appropriately to spoken statements; it even refers to seemingly simple things like the digital assistants on our mobile phones.

Where do you think the boundary lies between AI and machine learning?

Wrobel: Right at the dawn of artificial intelligence, AI pioneer Alan Turing knew that it would hardly be practical to program intelligent computers down to the very last detail. As early as 1950, he wrote that there must be a faster method – namely machine learning. With these methods, computers are able to learn from observations, existing data and examples and thereby improve their performance.

"This means that humans will do a smaller range of work. And that we can train intelligent systems."

Prof. Dr. Stefan Wrobel

Can these intelligent computer systems be compared with human intelligence?

Wrobel: You can always compare two things, even if they are different in nature. Just as an airplane doesn't fly like a bird, so a computer doesn't think like a person. We have to observe the outcomes and then judge whether we would classify them as less intelligent than, more intelligent than or equally intelligent as what a human would accomplish. In this regard, computers have already achieved major breakthroughs, such as winning the game show Jeopardy or cracking the game GO – to say nothing of chess.

Would it be accurate to say that, for things like strategy and image recognition, AI is now just as good as people, or even better, but that humans still have the upper hand when it comes to creative endeavors?

Wrobel: I think it's no longer quite so easy to make this generalization today. It depends on whether a computer can actually learn an activity from examples. Can the requisite knowledge be modeled in advance? Whether the implementation then involves a creative element or not – that's a deeper philosophical question.

In online interactions, we must now ask: How long does it take me to identify AI in action? For customer service and support queries, the first thing we encounter nowadays is often a chat bot.

Wrobel: We cannot confirm artificial intelligence in a philosophical sense; all we can do is demonstrate the non-distinguishability of human-human interactions from human-machine ones. Of course this can be very useful for practical purposes. If you consider companies that would like to use AI for customer contact, for instance: machines can already provide simple functionalities and straightforward answers at the first level.

Neural network is another buzzword in the AI community. What does it mean?

Wrobel: Neural networks are a machine learning method originally inspired by biology. The term refers to a sequence of functions that calculate outputs over several layers from a certain amount of inputs. Over the past few years, we have acquired the ability to train such networks even when they have a wide variety of parameters – into the hundreds of thousands, or even millions – across multiple levels.

"Neural networks are a machine learning method originally inspired by biology."

Similarly to how the human brain works, this kind of network is able to determine, structure and represent intermediate results in a completely different way, allowing it to accomplish much more. This is made possible by algorithmic progress and the massive amount of training data we have available today. The selection of this data is hugely important, especially when we decide not to model knowledge in advance, thus waiving the opportunity to incorporate certain guiding principles into the system. Another important factor is the strong growth in computing power.

We often read of "strong" and "weak" AI. What exactly is the difference?

Wrobel: This discussion has been around for many decades, and there is no universally recognized rule. The

debate around "strong" and "weak" AI is about whether we classify AI merely as "exhibiting intelligent behavior," which would describe "weak" AI, or whether AI ultimately functions just like a human mind, which we would characterize as "strong" AI. This then gives rise to the related question as to whether we would attribute consciousness or even accord personal rights to an artificially intelligent system – be that in an emotional, philosophical or merely legal sense. Behind this lurk the fascinating questions: In a profound sense, what is intelligence and what is creativity? How should we accept artificially intelligent systems? How should we treat them? It's worth discussing these questions in depth.

Does this raise the question as to whether an AI system must behave ethically or morally?

Wrobel: It would never be acceptable if an AI system were to behave in a less ethical, less moral, less proper, less socially acceptable manner than a human. Of course we have to apply at least the same standards to AI systems as we do to people. In fact, we should apply higher standards, as AI systems do not get tired and are never emotional or lacking concentration.

"It would never be acceptable if an AI system were to behave in a less ethical, less moral, less proper, less socially acceptable manner than a human."

What that means in concrete individual cases will, of course, be hotly contested. We're all familiar with the debate about self-driving cars. However, I think the discussion will become less complex precisely because of the capabilities and reliability of machine systems. If AI systems prevent dangerous situations from arising in the first place, we have to view that as a plus. Essentially, I hope that society as whole engages in a thorough debate about what artificially intelligent systems should do and should be able to do and what they should not do.

How are companies already using AI today?

Wrobel: In the field of image processing, for example, intelligent solutions have long been used in industrial environments, and now they have become even smarter thanks to their ability to learn – for instance, machine vision systems are already in operation across the whole spectrum of manufacturing, industry and visual inspection. Applications that are more familiar to the general public include systems for self-driving cars, chat bots and user interfaces – for example, the much-improved ability of computers to process speech.

What is the current state of research in AI?

Wrobel: Over the past few years, we've seen impressive progress in the possibilities of very parameter-rich, deep neural networks that we can actually train. And we're far from the end of this progress. In the next few years, it will become important to also reincorporate other, knowledge-based AI techniques. This is a research area that we have singled out as a priority at Fraunhofer, too.

"In the next few years, it will become important to also reincorporate other, knowledge-based AI techniques."

Take medicine for example, where it's still very costly to procure the requisite data for large-scale analyses. Or take industry, where medium-sized enterprises simply do not have millions of posts of a video or picture agency at their disposal, rather just 500 or 1000 individual classifications that were compiled in-house. This will be a major and highly important development.

What do you think companies should do now as regards AI?

Wrobel: Companies should apprise themselves of the current possibilities of AI and look at examples – and then think about how they can use these opportunities. This must happen at the highest level, because it affects the fundamental design of the company's business model and the company's positioning. You can't become a business that uses artificial intelligence if you aren't also a data-oriented, data-driven, digitalized company. If data is the key resource you want to work with, then this data must be secure. If it is, in fact, an asset, a trump card that you want to use to operate in the market, then you have to consider the following: Who can you share this data with, who do you want to build up these business models with? What data can you collect and what data are you allowed to collect? What is the cyber security situation? Accordingly, my simple message is: Start now. Invest now, build up skills and know-how, look for the right partners. This is why Fraunhofer integrates AI support into our consulting for digitalization and for big data, as these questions are closely interrelated.

www.iais.fraunhofer.de

MYTHBUSTING

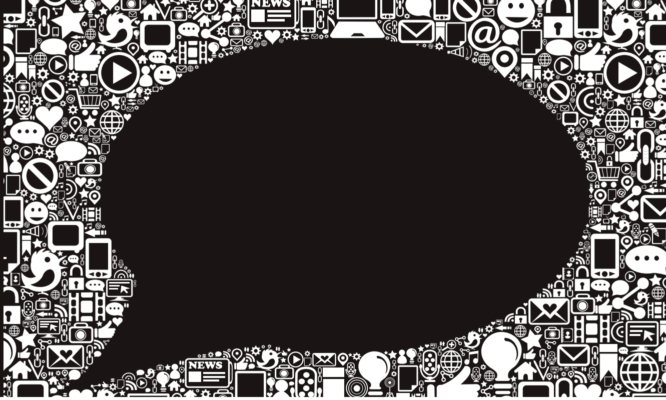
Dr. Hans Meine and Dr. Markus Wenzel at the Fraunhofer Institute for Medical Image Computing MEVIS scrutinize myths and clichés about artificial intelligence.

"AI creates artificial brains"

We're not building artificial brains or artificial people any more than an aircraft manufacturer is trying to build an artificial bird. They just want to construct something that flies. We build machines that perform elementary cognitive tasks that require intelligence. Such machines and mechanisms have already become part of our everyday lives: there are devices that control cars, understand human language and carry out simultaneous translation. But even if we teach a machine individual skills – lip reading, for instance – so successfully that it can perform them better than humans, that does not automatically make it an intelligent device.

"Decisions made by AI systems are more neutral and objectiv"

That is not true. AI systems have no intrinsic motivation or self-interest in being neutral or objective. They are dependent on the training material and on the trainer's intentions. Ultimately, a machine is trained to process an input and deliver an output. In the field of medicine, for example, if a machine is trained to detect malignant changes in the liver on CT scans, it is not able to find malignant changes in the spleen, kidneys or lungs. We need humans to review and be responsible for machine-assisted decisions.



"AI makes medicine cold and impersonal."

On the contrary! Nobody wants to lose the human aspect in medicine. But what does "human" actually mean here? Inattentiveness, lack of knowledge and misjudgment are human characteristics, but they clearly offer no advantages when it comes to medical diagnosis. Computers help people to make safer and more accurate decisions when faced with large volumes of data. They process information much faster, with greater reproducibility and usually demonstrably better when dealing with simple cognitive tasks. In this way, computers help doctors to bring more of their positive human characteristics to their everyday clinical practice. For example, if AI carries out monotonous tasks, this frees up more time for doctors to listen to their patients with sensitivity and – drawing on their broad medical knowledge and experience – offer sympathetic guidance to patients in emotionally stressful situations.

"AI has no place in matters of life and death."

Wrong! AI provides valuable assistance precisely in instances where correct decisions are needed fast. Most human errors occur when there is complex information to process, when there is significant time pressure and when the general circumstances are unfavorable. An AI system that scans a case once more and raises a flag when something may have been been overlooked is very useful. It sorts information by order of importance and provides doctors with valuable support.

www.mevis.fraunhofer.de

QUANTUM COMPUTING: DRAMATIC PROGRESS IN ARTIFICIAL INTELLIGENCE

What sounds like science fiction could be part of our everyday lives in just a few short years. Pioneering companies have already developed quantum computer models and are working feverishly to get them ready for market. Prof. Dr. Christian Bauckhage at the Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS explains the background.

Quantum computing will soon be on everybody's lips. How does it differ from conventional computing?

Bauckhage: With conventional, digital computers, the smallest unit for representing information is the bit, which has a value of either 0 or 1. In quantum computers, individual electrons are manipulated, and the calculations are based on the principles of quantum mechanics. A quantum bit, as it is known (or "qubit" for short), is 0 and 1 simultaneously. It only "decides" when we measure it. Until a physical measurement is carried out on a qubit system, we can only say with a certain probability whether it is 0 or 1. That sounds bizarre and confounds our everyday intuition, but that's how nature works at the subatomic level. We have to rely on mathematics, which is extremely complex in this case. But people have been able to describe these processes mathematically since the 1930s.

How advanced is the research today? Are quantum computers already in use?

Bauckhage: A Canadian company that manufactures quantum computers sold

Prof. Dr. Christian Bauckhage

them to NASA, the NSA and Google for 15 million U.S. dollars. VW Research leased these systems, which follow the adiabatic quantum computing paradigm. At the same time, IBM has its own quantum computers, which follow the quantum gate paradigm. Essentially, this is the attempt to translate the logic gates used in digital computers – that is, "AND," "OR" and "NOT" – into quantum mechanics. Intel and Microsoft are also working on such models. Google announced that, by the end of 2017, it would have a quantum computer with 49 quantum bits, which would achieve so-called quantum supremacy – in other words, be able to compute much faster than a classical computer. Quantum computers are now just an engineering problem; they merely have to be made smaller and cheaper.

What are the hurdles and challenges involved in the manufacture of quantum computers?

Bauckhage: The hurdle is something called decoherence. When two elementary particles collide, it is akin to a measurement, and the effect of the two simultaneous basic states disappears. So the difficulty is to manufacture devices in which quantum states can be isolated such that they are prevented from interacting with other quantum particles. There must be no outside influence from temperatures, vibrations, mechanical movements or radiation. Achieving this requires very low temperatures, vibration-free mounting and sometimes lasers.

That sounds very exacting. What advantages do quantum computers have over classical computers?

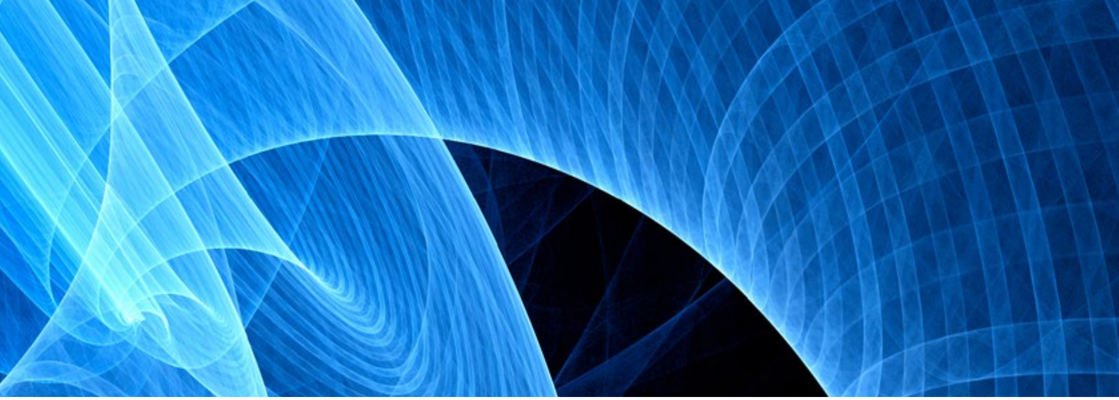
Bauckhage: A qubit has two possible states. Two qubits have a total of four possible states; three qubits, eight states; four, 16; and so on. The situation is similar with digital computers. Four bits can represent a total of 16 digits – but only one of these 16 digits at a time. Four quantum bits, in contrast, represent the 16 digits simultaneously. Understood mathematically, this enables us to solve exponentially difficult problems in so-called polynomial time. The classic example is encryption: When the numbers used for encryption are large enough, a digital computer would need billions of years to crack an encryption code, as it would have to work its way successively through a mind-boggling number of combinations. A quantum computer, on the other hand, tests all these combinations simultaneously. Instead of taking billions of years, this computation lasts just a few seconds. Quantum computing will change everything. No online banking transaction will ever be safe again.

You see a potential danger here?

Bauckhage: The potential danger does not reside in the fact that we will be able to use quantum computers, but that our encryption algorithms may soon no longer be adequate.

In machine learning, algorithms solve problems by evaluating large amounts of data. Will quantum computing then accelerate this process?

Bauckhage: Machine learning is statistics. The parameters of statistical models are optimally adapted to data. On classical computers, these optimization problems are expensive and time-consuming. Thanks to powerful conventional computers, we've still managed to make great advances in this field. However, quantum computers are ideal for solving these optimization problems very quickly. Within a short period, computers will learn processes that currently take them months to learn. Whereas, at present,



separate special programs are needed for such functions as image recognition, speech recognition and process planning, soon a single program will do all of this. Multiply today's capabilities by a thousand and you will get an idea of what's coming. Much more complex problems will be solved and then marketed. We're going to see dramatic advances in artificial intelligence.

I suppose quantum computers will initially be the preserve of big companies? And these companies will then sell solutions in the form of services?

Bauckhage: Indeed. And that will present us with some major challenges. For example, we're going to run into problems in IT education and the IT job market. People who have studied theoretical physics will be in high demand, but for everyone else, things will be challenging, because quantum computing is based on special kinds of algorithms and very complex math. In Germany, there are currently very few people with the kind of training needed to work with this technology.

Are there any initiatives yet in Germany that deal with quantum computing?

Bauckhage: Research has always played a prominent role in Germany, and quantum computing is no exception. For example, the German Federal Ministry of Education and Research decided to set up a national initiative called Quantum Technology – Fundamentals and Applications (QUTEGA) to promote quantum technologies in Germany. And quantum research is also a major topic at the Fraunhofer-Gesellschaft. I'm personally responsible for everything relating to quantum computing for machine learning. If the technology is going to be standard in five years, we need to be prepared.

www.iais.fraunhofer.de

AI IN THE FIGHT AGAINST CYBER ATTACKS AND ANOMALIES

Digitalization and connected Industrie 4.0 form the basis for complex applications and new business processes – while also providing targets for all kinds of IT-based attacks. New discoveries in machine learning are helping to improve early detection and prevent disastrous consequences from cyber damage.

With respect to digital innovations, we are currently in the middle of a period of super-fast development. All signs indicate that connectivity and automation will become ever more comprehensive – using technologies such as the Internet of Things (IoT), big data, blockchain, machine learning and artificial intelligence. People, companies and organizations are revolutionizing their processes, their entire manufacturing operations and the corresponding work environments. These trends and developments create huge advantages in efficiency and connectivity, but they also present users with ever greater challenges – such as in matters of cyber security.

The reason is that data volumes and data complexity are growing by leaps and bounds. Some security engineers and analysts are increasingly overwhelmed in the face of an exponentially rising number of cyber threats. For potential attackers, it is becoming ever easier to carry out malicious attacks on their selected targets – they can access various publically available hacking tools and, with the requisite know-how, use countless computers belonging to strangers as "bots" in order to disguise their misdeeds or gain unauthorized access.

New security through AI

To respond to these dangers of the connected world, the development of innovative security technologies is becoming increasingly vital. These technologies must help us analyze potential threats and malicious behavior in cyberspace more effectively, and also understand them better – only by doing this can we provide securer systems and adequate protection mechanisms to promptly deal with the threats. To this end, the Fraunhofer Institute for Applied and Integrated Security AISEC is turning to intelligent cognitive security technologies. The security researchers use complex AI algorithms to continuously improve both software and hardware security in current IT systems. By using neural networks and machine learning techniques, the new cyber security systems are able to learn continuously from data in order to adapt dynamically to changes in operational scenarios – allowing them, for example, to reliably discover anomalies.

Detecting, analyzing and evaluating cyber attacks

Using artificial intelligence in this way, security engineers can process their daily tasks on a large scale and at high levels of complexity. For this purpose, Fraunhofer AISEC is designing and developing scalable security solutions for the detection, analysis and swift evaluation of online attacks and offers direct solutions, new protection mechanisms and best-practice applications from the field of machine learning. Close cooperation and constant dialogue with further prominent security experts ensure the requisite further development of AI-based security technologies and lead to customized solutions to meet the individual challenges of all customers.

http://s.fhg.de/cybersecurity

PARADIGM SHIFT: DEEP LEARNING ON SUPERCOMPUTERS

Despite a raft of pioneering developments, a paradigm shift is needed in machine learning, as the current demand for data and computing power to calculate the learning models is growing much faster than the quality of the calculated solutions, explains Dr. Janis Keuper at the Fraunhofer Institute for Industrial Mathematics ITWM.

Machine learning has become a necessity, since the demands we place on IT systems have increased enormously.

Keuper: Think of self-driving cars, which have to assess traffic situations correctly; or think of speech recognition or "recognizing" the content of a picture: these are all capabilities that a computer or its software is now supposed to reliably master. But this is not feasible if you try to capture human intelligence in algorithms using classical methods. You have to exploit the advantages of data-driven approaches, such as deep learning. These approaches have yielded impressive results, particularly when we compare them with the results of classical logic-based systems.

Does that not push hardware to its limits?

Keuper: Machines learn by digesting huge amounts of information in a data-driven approach. The masses of data this requires leads to a situation whereby the high-end shared-memory multi-GPU systems conventionally used for this

Dr. Janis Keuper

purpose need several days to calculate a medium-sized model. Consequently, the maximum computing power obtainable in a local system is scarcely able to keep up with the requirements of machine learning. That's why I see the algorithms used in machine learning as standing on the cusp of a fundamental change: we need the switch to distributed calculation on heterogeneous high-performance computers (HPC).

What you're advocating focuses on learning itself, is that right?

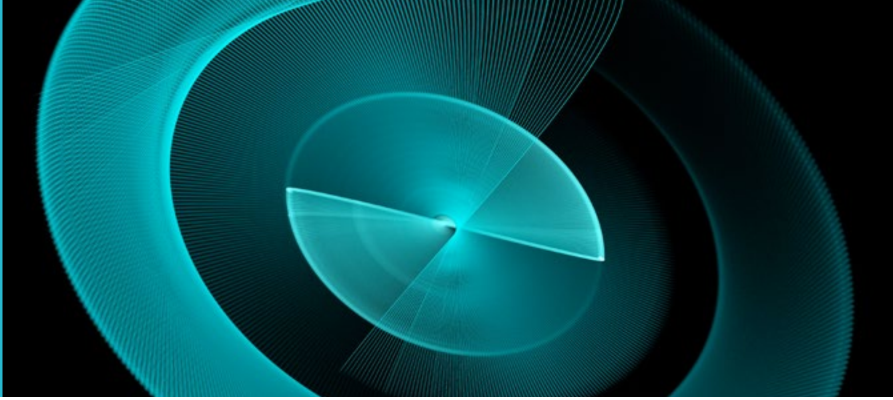
Keuper: With HPC, the computational effort always relates to the actual learning process. Once something has been learned, the software could then even run on your smartphone. But learning requires a huge amount of effort. Let's take, for example, the automotive industry, which requires a large number of different algorithms for its self-driving vehicles – for the driving itself and for recognizing traffic signals, pedestrians, etc. These models have to be pre-trained, increasingly on mainframe computers. At Fraunhofer ITWM, we're working on methods that enable HPC to be used better and more easily for deep learning. A key problem here is the question as to how the masses of data can be channeled through the actual computation process in the first place. We're currently in the range of 10 to the power of 15 or even 10 to the power of 20 computing operations. That's why we're trying to get a handle on the requisite data transport at essentially all the different levels – including mathematical models that scale down the amount of data, communication protocols, and hardware to speed up the transportation. This is also the object of such projects as the High Performance Deep Learning Framework, which we're carrying out on behalf of the German Federal Ministry of Education and Research.

www.itwm.fraunhofer.de/ml

INTELLIGENT SEPARATION

Centrifuges used to mechanically separate substances play a key role in industrial food production. Ensuring that the machines run on the optimum settings has traditionally depended on the experience, intuition and sense of hearing of a human operator. Now this knowledge has been successfully transplanted into an expert system that uses artificial neural networks.

In industrial practice, many things are considerably more difficult than they appear in the classroom or lecture hall. Whether in the chemical industry, the pharmaceutical sector, mineral oil processing or the food sector, the processes needed to separate various substances are often much more complicated than the textbook separation, for instance, of solids and liquids using the maximum centrifuge settings available. On top of this, tens of thousands of liters have to be separated every hour in industrial applications. "There are normally several phases of separation here. When processing raw milk, for example, skim milk, cream and various solids have to be cleanly separated," explains Sebastian von Enzberg at the Fraunhofer Institute for Mechatronic Systems Design IEM. "If separators are not precisely set and continuously adjusted, losses in quality and damage to products may result." For a long time, correctly setting separators was based on the intuition and hearing of the respective centrifuge experts – usually the manufacturer or machine operator. "Characteristic noises and vibration patterns are often the only indicators of an optimal separation process or a need for readjustment," says von Enzberg.



Complex sensor systems and intelligent data processing

Installation of sensors that monitor and supervise processes is costly and difficult, because they have to continuously supply data from the machine in the millisecond range, and this data also has to be measured at a wide variety of positions during rotation. The research team at Fraunhofer IEM has now managed to fit sensors not just to the casing and drain pipe, but also to the interior of a rotating container. These sensors are able to perform and transmit up to 48,000 measurements per second.

But all this data also has to be processed quickly and intelligently so that the centrifuge can ideally be controlled in real time. "The goal of intelligent data processing is to emulate the perception capabilities and judgment of a human operator," emphasizes von Enzberg. "That's why we adopted machine learning and used artificial neural networks and the vast amounts of data we had accumulated to train a system we programmed ourselves. The system is able to recognize error states and develop strategies for adjusting machine parameters in order to then fine-tune the machine in fractions of a second even while in operation."

This knowledge can also be transferred to the handling of different centrifuges and tasks, provided that the machines and systems are equipped with suitable sensor technology and that the database is large enough. Once the learning process has been concluded, centrifuges will soon also be able to work autonomously and with remote monitoring.

www.iem.fraunhofer.de

TRENDS & PROJECTS

A glimpse inside the black box

Today's models for AI and machine learning are large (gigabytes) and complex – and therefore energy-hungry during implementation. As a consequence, the models can be run on high-performance computers but not on embedded devices, IoT devices or smartphones. The Fraunhofer Institute for Telecommunications, Heinrich Hertz Institut, HHI is developing techniques to reduce the complexity of neural networks and compress them without losses in performance. For the use of machine learning in critical applications, the institute is also developing methods to analyze neural networks in greater depth. This would make it possible, for example, to verify that the AI's solution path makes sense and that it is on the right path to the right results, offering a glimpse inside the black box, as it were.

www.hhi.fraunhofer.de

MCube microscopy system

According to estimates by the WHO, some 214 million people were affected by malaria worldwide in 2015, with approximately 438,000 deaths. The disease is caused by parasites of the genus Plasmodium, which can be detected in blood smears by microscopic examination. However, the microscopic examination can be very time-consuming when there are only a few pathogens in the sample and a large number of fields of view have to be examined manually. As part of a multidisciplinary project sponsored by the Fraunhofer Future Foundation, the Fraunhofer Institute for Integrated Circuits IIS developed MCube, a computer-assisted microscopy system for automatically recording blood smears and detecting malaria pathogens based on artificial intelligence methods.

www.iis.fraunhofer.de

Optimized energy networks

Thousands of kilometers of new grids are to be built in Germany by 2020 to utilize energy from renewable sources. Intelligent grids entail greater complexity, costs and vulnerability. The MYNTS (Multiphysical Network Simulator) software created by the Fraunhofer Institute for Algorithms and Scientific Computing SCAI helps with the planning and operation of complex electricity, gas and district heating networks. It can be used to calculate things like how changes in, or even failures of, sub-grids affect the remaining grid components, or how all compressor stations in a gas network can be operated in an energy-efficient manner. A new development also takes into account cross-sector networks and flexibilization options, making it cheaper for network operators to expand networks and giving them greater flexibility, as well as enhancing security and protecting the environment.

www.scai.fraunhofer.de

DeepER: Modern document analysis

Optical character recognition (OCR) technologies will soon benefit from the breakthroughs in the field of AI. This is the premise of the "Deep learning based optical character recognition" (DeepER) research project. As part of the project, which is funded by the Federal German Ministry of Education and Research, the Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS is working together with partners on a new piece of software for reliable document analysis. The project uses deep learning methods to create learning, intelligent systems that are expected to deliver substantial technological progress. Optical character recognition (OCR) will be used, for example, in the digitalization of library contents, newspaper archives and insurance documents.

www.iais.fraunhofer.de

TRENDS & PROJECTS

Intelligent container management

A lack of information about the actual size of inventories in container cycles leads to higher costs and longer delivery times. The DProdLog research project by the Fraunhofer Institute for Integrated Circuits IIS and the Fraunhofer Center for Applied Research on Supply Chain Services SCS addresses this need for precise control of containers in production supply – and ensures greater quality and revenue through a digital, modular service platform. Smart small load carriers featuring s-net® as a basic IoT-technology permit data-based services that are capable of, for instance, autonomously triggering resupply processes, recognizing bottlenecks in the value creation chain, adjusting scheduling and visually notifying employees.

www.scs.fraunhofer.de

Bin picking

Experts at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA are working on ways to apply machine learning techniques to industrial applications. A collaboration between Fraunhofer IPA and the University of Stuttgart, the DeepGrasping project tackles the problem of how to optimize robot-based bin picking – that is, the automated separation of unsorted workpieces. Previous solutions use recognizable characteristics and fixed recognition methods for object recognition. Now the requisite algorithms (for object recognition, position estimation, gripping, manipulation, etc.) should be able to optimize themselves autonomously. A neural network learns from a large number of simulated grips and continuously improves its process knowledge and thus also calculation times, success rates and process reliability of the grips.

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Process industry 4.0

The Fraunhofer Institute for Factory Operation and Automation IFF is developing a new, digital monitoring process that harnesses Industrie 4.0 techniques for the process industry and for companies in the chemical and pharmaceutical sectors, for example, as well as in steel and cement manufacturing, and for their respective suppliers. This process efficiently combines production data and employee knowledge.

The new process will connect systems for maintenance on three levels. The first level concerns the life cycle: the experts use systems planning documents for the operation of the machine – for example, the 3D CAD model created during the planning of the production system. If a worker needs information about a specific component – a pump, for example – he or she scans the pump's QR code on a tablet computer, which then displays all existing planning documents relating to this component. In addition, the worker can view operating data, such as temperature and pressure curves. When it comes to troubleshooting, the digital twin is also able to help. For every error reported by the control system, the researchers plan to create an interactive recommendation for action.

The second level is vertical connectivity, whereby the sensors fitted to the machines send the status data they collect to the cloud. This makes it possible to implement predictive maintenance approaches even for these process engineering systems. The third level will connect the running production system with the supply chain. If a seal in a machine has to be replaced, for example, the employee receives an immediate notification whether the part is in stock in the warehouse.

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Editotrial notes

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