The centaurs

21/03/2019 Germany wants to use artifical intelligence to reinforce its position as a leader of global industry. Porsche is promoting the use of centaur systems that combine capabilities of people and machines. What’s the potential?

First came checkmate, followed by losses at poker and the strategy game of Go: having stepped up in defence of humanity on 11 May 1997, former chess world champion Garry Kasparov was forced to concede after the sixth game against the IBM computer Deep Blue. Two decades later, the supercomputer Libratus from Carnegie Mellon University outdid the top poker players in the world in the gambling mecca of Las Vegas. At roughly the same time, Chinese Go player Ke Jie, at the time the best player in the world, was defeated by the Google program AlphaGo.

Mere games have become a grinding daytoday reality: more and more, artificial intelli gence (AI) seeks to emulate human perception and human behaviour through machines. What once began as a method of computer programming is increasingly linked to the study of human thought.

Digital assistants and learning machines are intended to aid people

Digital assistants and learning machines are intended to aid people – make their lives easier, safer and more predictable. They analyse the usage behaviour of customers, predict life expectancy, find the best candidate for a job, speculate on the stock market, comb business reports and warn of dangers before they occur. If one believes the consultancy McKinsey, the application of AI could boost value creation to the tune of 13 trillion dollars by 2030. This in turn, would amount to a 1.2 % annual increase in global GDP over the growth rate that would otherwise be expected. In contrast, the introduction of industrial robots in the 1990s, say the consultants, added just 0.6 % more growth per annum.

The message has been received: in November 2018, the German federal government launched an “artificial intelligence” strategy aimed at promoting both research in Germany and applications in the private sector. As part of the strategy, the government has mooted billions in additional investments as well as the prospect of 100 additional professorships at universities.

Powerful neural networks, with the aid of which machines can analyse unstructured information such as video images, were already available in the late 20th century. The enormous computing capacity required for the task, however, could only be achieved with roomsized supercomputers at research centres. The exponentially growing data volumes, driven initially by the pursuit of everbetter graphics in computer games, are today handled by machines roughly the size of a refrigerator. Using smartphones and smart speakers at home, today anyone can access such servers from almost anywhere.

AI systems are highly specialised

Current AI systems are highly specialised: some have learned to analyse images of human faces, while others recognise the meaning of spoken commands. Still others comb through massive reams of data for meaningful correlations.

In some areas, this “weak” artificial intelligence equals or even surpasses human intelligence. “Strong” artificial intelligence, by contrast, operates on at least the same level as the human brain – imaginable, but still in the distant future. “It will probably be a matter of decades before machines have even re motely the motor and cognitive capabilities of humans,” says Frank Kirchner of the German Research Centre for Artificial Intelligence (DFKI) in Kaiserslautern.

Humans routinely work hand in hand with robots in hybrid teams

Even today, humans routinely work hand in hand with robots in hybrid teams, supported by intelligent assistance systems. The factory of the future is flexible, safe and capable of producing anything from mass production runs to single units with optimal resource utilisation.

The potential of AI in the medical field is demonstrated by the digital heart twin. Thirty to 50 % of patients undergoing cardiac resynchronization therapy (CRT), in which a pacemaker is implanted, do not respond to the treatment. The digital heart twin uses artificial intelligence to assess the chances of success more accurately and plan the treatment with greater precision before the procedure is carried out.

Curiously, the pioneer of the humanmachine team was none other than the defeated chess genius Kasparov: this combination, he says, is capable of beating the fastest computer working on its own. In Greek mythology, the centaur combines the intelligence of a human with the speed of a horse. Socalled centaur systems are at the centre of all developments with which companies aim to enhance their productivity through artificial intelligence: in administration as well as in production or sales.

Mattias Ulbrich, the new Chief Information Officer (CIO) at Porsche since September 2018, sees artificial intelligence as a corner stone of the IT strategy: the aim is not to displace human work, but rather to complement it effectively. “Artificial intelligence increases productivity all along the entire value creation chain,” says Ulbrich. “In the future, people will therefore have more time to focus on essential tasks.” Ulbrich sees these typical essential activities as including finding creative solutions, leading discussions and making the right decisions in complex situations: “Just as physical strength no longer determines who is a good worker in production, purely formal qualifications will likewise be much less relevant in the future.”

Together with all departments, in a first step Ulbrich identified suitable fields of application for AI technologies. In the procurement and finance departments alone, more than two dozen potential applications were picked out. The Porsche Digital Lab in Berlin is also forging ahead with the issue. "But there is a big difference between what is potentially possible and the actual need for stable systems for ongoing operations," says Ulbrich. For example, the use of AI methods only makes sense where there is highquality data available: "We span the gap between two worlds."

Porsche is investing in its own centre of AI expertise. The aim is to assemble 30 to 40 experts over the coming two years. The goal is by no means an easy one; qualified personnel in this fastgrowing field are scarce and highly selective. Ulbrich is nevertheless optimistic. His drawing card: the way in which Porsche aims to use AI both in the vehicle and in processes of the factory of the future.

Porsche developers rely on machine learning

Take the example of motor racing: in June 2018, a Porsche 919 Hybrid Evo pulverised the 35yearold lap record for the Nurburgring's Nordschleife by almost a minute in spite of changes to the "green hell" in the intervening years that made it even more demanding than it already was. Spoilers on the rear of the race car that could be adjusted on the fly ensured optimal downforce in every section of the track. Simulating in advance all of the geometries and adjustment options of the spoilers, not to mention their reciprocal effects on each other, as well as the course characteristics using conventional methods would push even highperformance computers to the very limits of their capabilities. Porsche developers therefore rely on machine learning – and are making motor racing history in the process.

Data determines many management decisions

The procedure, tested on the toughest race track in the world, says Ulbrich, will eventually be applied to the management of the entire company. Data already determines many management decisions. In most cases, those decisions are based on the past or uncertain forecasts. Realtime data can enhance the quality of those decisions. In view of the abundance of information, such a system to assist top management would be unthinkable without AI methods.

Another form of support for human work is being investigated by Porsche Digital Lab. One of the research specimens in this case is a coffee machine. The background: AIbased imagerecognition software is highly developed. However, the sounds that a system makes often reveal more about its condition than its appearance. If you seed an AI system special ised in pattern recognition with typical sound patterns, it can detect deviations and sound the alarm. Just as a careful driver stops as soon as the engine starts making odd sounds, a system of this sort provides a warning before damage occurs.

A system for sound analysis

"Every mechanical system has its own acoustic fingerprint," says Claudio Weck, an employee at the

Digital Lab. "Deviations are almost always indications of a significant change in the system behaviour." However, it is not easy to detect such deviations in a loud environment such as a production hall. Acoustic vibrations overlap each other – rather like the waves on a lake when a stone plops into it. For this reason, sound analysis with conventional, computeraided analytical methods quickly reaches its limits unless conducted in a soundproof acoustic laboratory. The capabilities of neural networks, by comparison, were tested by the team using the coffee machine. They later presented the findings of their work at a Porsche inhouse fair. The results literally clicked for one production manager. In vehicle assembly, many electrical contacts must be connected. In some cases, the engagement of the connector can only be heard through the typical clicking sound. Although the entire vehicle electrics are tested after assembly, in certain borderline cases an electrical contact is established even where the connector is not fully engaged. With the idea from the lab, a system for sound analysis can provide absolute certainty.

The sound detective has a plethora of other potential uses as well. A test bench at the Porsche Development Centre in Weissach tests the proper functioning of the electrically retractable exterior mirrors. The test runs in continuous operation. And it's not just the stability and smooth motion that are being examined. The sound pattern should also remain constant – a demanding and timeconsuming task for the person manning the test bench. With an AI system, the employee could leave the listening station and prepare the next endurance test.

Joachim Deisinger is the person responsible for virtual vehicles at Porsche. One of the goals is to reduce the number of construction phase vehicles by half by 2025. Construction phase vehicles are real prototypes, partly built by hand, for tests in the development phase. Now those prototypes will be replaced by virtual models in a stepbystep process. This not only saves time and money, but is also good for the environment by using fewer resources. And that, particularly with regard to automated driving, is an absolute necessity. It is estimated that roughly 240 million test kilometres would be required to validate all situations that such a vehicle can get into. Every model would have to circumnavigate the globe some 6,000 times before it had taken on every hurdle – "simply impossible," says Deisinger. His answer: simulation.

A candidate for every occasion

There is, however, a critical difference between physical and digital prototypes. A real car hits the race track for dynamic testing. In crash tests it hits the wall – it's an allrounder, a jack of all trades. Digital prototypes, by contrast, are specialists. For crash tests, for example, socalled finite element models are used. In finite element models, all of the vehicle's components are broken down into very small geometric elements. This makes it possible to calculate with great precision the forces within the vehicle structures in an impact with a defined obstacle. For vehicle dynamics development, a complete chassis is mapped in a multibody simulation and then tested on virtual circuits. In this manner, developers build 18 different digital prototypes for each new Porsche model.

AI systems gain currency particularly in scenarios involving large volumes of data, which is a defining characteristic of virtual development. It begins as soon as the data is gathered. A Porsche consists of 10,000 to 15,000 individual components, manufactured by individual departments and a multitude of suppliers. The design data for each individual part is stored in a file management system, with qualified engineers entering and structuring the data – a tedious and unproductive job. "What if we automated such processes using artificial intelligence?" asks Deisinger. "We're creating space for creativity."

Multitude of potential AI applications

It is now paying dividends that Porsche invested in digital development at an early stage. Tests with real and virtual prototypes generate huge volumes of data from which insights can be gained using AI methods. This opens the door to a multitude of potential AI applica tions. They reduce the number of actually driven test kilometres and improve product characteristics. Machine learning can help generate elements like drag coefficientoptimised vehicle geometries such as the rear wing of the 919 Evo. And the procedure can be applied to series development as well. Neural networks make it possible to examine a larger number of geometric variants for their potential suitability without the computing time going through the roof. Data analysis of real and virtual tests becomes a simpler affair as pattern recognition enables faster detection of salient deviations from the target and average values.

Artificial intelligence us, however, by no means infallible. While supercomputers can rapidly process huge amounts of data statistically significant correlations, they cannot identify causes and effects if they were not defined by a person in advance. Harvard Law student Tyler Vigen founded a website that publishes spurious correlations. According to the numbers, the number of civil engineering doctorates in the US correlates to per capita consumption of mozzarella. A human immediately knows: pure coincidence!

One fundamental problem is the quality of the data that is used to train neural networks. An AI system identified a husky as a wolf because all of the images showed wolves in snow – including the one with the husky. The system was not able to explain its decision.

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