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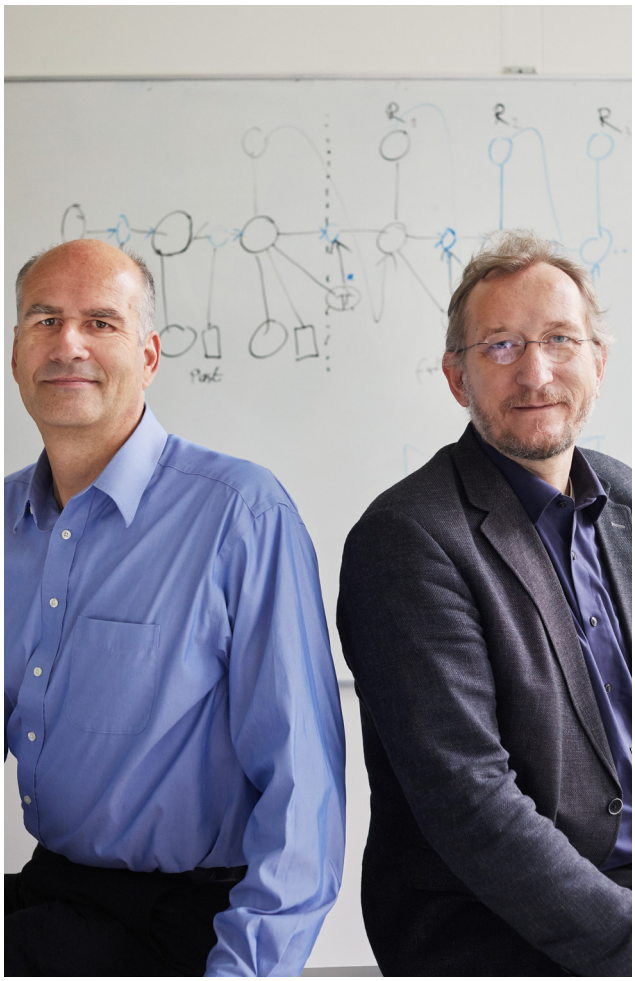
Machine learning

# Volkmar Sterzing and Steffen Udluft rank among the first inventors of data-efficient AI applications in the world.

Teaching artificial intelligence to do something with the help of mountains of data is a pretty simple job, relatively speaking. But things really get interesting when you turn those mountains of data into molehills, as the inventor team in the category Outstanding Invention has demonstrated: Volkmar Sterzing and Steffen Udluft of Corporate Technology in Munich.



**Volkmar Sterzing (left) and Dr. Steffen Udluft**

Head of Research Group Learning Systems, Senior Key Expert Research Scientist, in Munich, Germany

**Volkmar Sterzing (left) and Dr. Steffen Udluft**

Inventor of the Year 2017

## "In the near future, a machine that has already learned from data will be more valuable than a brand-new one."

The gas-combustion process in the combustion chamber of a turbine is a tricky one: The cocktail of gas and air travels from the valves into the chamber, where it ignites. Temperatures climb to levels of around 1,600 degrees Celsius. Many factors determine the outcome of such questions as how the gas burns, whether powerful combustion dynamic occurs, how much nitrogen oxide is created and how long a gas turbine can ultimately stay in operation. The quality of the gas plays a role as well, just as the outside temperature and the required combustion performance.

For this reason, many experts are working to determine how the combustion process can be optimally controlled. This need prompted Volkmar Sterzing and Steffen Udluft to come up with the idea of using artificial intelligence to control a gas turbine. "Things always get interesting for us when a complicated system has to be controlled because so many measurement and control variables come into play," says Sterzing, who leads the research team Learning Systems at Corporate Technology.

But they entered uncharted territory when they got involved with applications of artificial intelligence that use small amounts of data. Long before other AI researchers became the proud parents of software that was able to win a world championship in such board games as Go, the Siemens experts were focused on optimizing complex industrial facilities with the help of AI. When the two began their research about 15 years ago, hardly any other expert in artificial intelligence gave much thought to using a reinforcement learning method that worked with small amounts of data.

For gas turbines, however, there was simply no other approach to take: "To enable the program to learn to control the unit during all possible situations by employing the amount of data generally used for reinforcement learning at the time, a turbine would have had to run around 100 years to supply the necessary data," Udluft says. Faced with this problem, the physicist developed a data-efficient method for reinforcement learning. It was work that put the Munich team well ahead of its peers around the world.

Today, Power Generation Services uses a system called GT-ACO (Gas Turbine Autonomous Control Optimizer) in pilot operations to control large Siemens gas turbines in the United States and South Korea. "We were surprised at how much better the gas turbines could be operated as a result thereof," Sterzing says in describing the results of the first test. The continuous fine-tuning of the combustion valves optimized gas turbine operations in terms of emissions and wear by constantly searching for the best solution in real time. "To ensure that a gas turbine runs optimally, you always have to search for a balance in which undesired effects in terms of combustion dynamics and emissions are kept as low as possible," Sterzing says. "If you improve one variable, you will worsen a different one. Artificial intelligence knows how to find the sweet spot."

The gas turbine is just the beginning. Sterzing and Udluft have already used their learning software to control a wind farm. Turbulent flows created by a wind turbine reduce the efficiency of the wind turbine behind it. This effect is felt throughout the entire wind farm. "You cannot analytically calculate this," Sterzing says. That made it an ideal case for learning software.

Siemens produces all sorts of complex systems: traffic control systems, industrial automation systems, medical diagnostic systems. The use of artificial intelligence is possible everywhere. "In the near future, a machine that has already learned from data will be more valuable than a brand-new one," Udluft says. "No one will buy 'dumb' devices and systems anymore when smart ones are available at comparable prices," Sterzing adds. The future has only just begun!

**Volkmar Sterzing** (52) has been fascinated by artificial neuronal networks ever since he studied information technology and computer science in Chemnitz, a city in eastern Germany. After earning his degree, he got an opportunity to apply his knowledge at Siemens Corporate Technology. "This was a really new research area at the time," he says. "My work focused on speeding up artificial neuronal networks with the help of special hardware." As part of this work, Sterzing spent nine months in Silicon Valley, which was the center of research into artificial intelligence (AI) at the time. In the initial phase of his research, Sterzing worked with his Siemens colleagues to develop software called SENN, which serves as a basis for the development of neuronal models. Thanks to his elaborate network in the company's divisions, the research group had an opportunity to turn its data-efficient methods in real industrial systems like gas turbines and wind power units into marketable products. He has registered 38 inventions during this period and 82 patents are already protected in 33 patent families.

**Dr. Steffen Udluft** (48) studied physics at the Ludwig Maximilian University of Munich. While earning his doctorate at the Max Planck Institute for Physics, he explored AI themes. In 2001, he joined Sterzing's research group Learning Systems. The physicist specializes in developing reinforcement learning algorithms that use small amounts of data to teach complex systems to learn from data. He has registered 36 inventions during this period and 96 patents are already protected in 28 patent families.

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