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What once sounded like science fiction will soon become reality: the creation of quantum computers that can perform highly complex calculations faster than supercomputers.



F.l.: Dr. Jürgen Fuß (FH OÖ) Hagenberg campus, PhD candidate Thomas Grurl, and Prof. Robert Wille (JKU)

Computer scientists from the Universities of Applied Sciences in Upper Austrian (FH OÖ), the Hagenberg campus, and the Johannes Kepler University Linz (JKU) have come together to combine their expertise in preparation for the new technology.

Together with the FH OÖ Department Secure Information Systems, the JKU Institute for Integrated Circuits is developing and testing algorithms used in quantum computers. These are highly complex formulas that virtually program these high-performance computers.

Today, these quantum algorithms can already be executed on the first commercially available quantum computers that have 20-30 quantum bit (Qubit) computing power, as recently made available by Google or IBM via cloud-based solutions. And users could soon have even more powerful processors at their disposal as both companies have developed computers containing over 50 quantum bits.

However, as not every quantum algorithm can be immediately executed on quantum computers without errors; they are first developed and tested "on a small scale" using simulators, before ultimately being executed on the real machine. This not only allows for an opportunity to simulate the algorithm's functionality, but also ensure that the concrete physical behavior can also be correctly represented, including potential errors that cannot be avoided with quantum computers.

This highly complex undertaking is known as "quantum simulation" and the JKU Institute for Integrated Circuits under Prof. Robert Wille, and Dr. Jürgen Fuß' team at the FH OÖ Department "Secure Information Systems" have several years of expertise in this area.

Profs. Fuß and Wille have been working closely with their teams since spring of 2019 and remarked: "We discovered our areas of expertise complement each other perfectly and we could join forces to support advancements in developing quantum computers, thus pursuing pioneer work right here in Upper Austria."

Under the management of Prof. Robert Wille, the JKU has been conducting research simulation and design methods for quantum computers for the past four years and the institute has even received several awards from Google and IBM, etc. The methods developed here allow applications to be converted "at the touch of a button" to descriptions with which the quantum computer can work with.

For the past two years, Dr. Jürgen Fuß and his team at the FH OÖ Hagenberg campus have been working on developing tools to program quantum computers and test them on the university's own Quantum Learning Machine at Atos, one of the world's most powerful commercially available quantum simulators.

Even today, simulation expertise 'made in Upper Austria' is internationally in demand. Methods developed here have found their way into official design tools at IBM and Atos. Experts at the FH OÖ and at the JKU are regularly in contact with companies active in this field, such as IBM, Google, Microsoft, and Atos.

Researchers at the two Upper Austrian universities see a wide range of potential application areas for their work that include financial service providers, the logistics and transport sector, and automobile companies. These types of companies are already investing in the new technology. Enormous progress can be made with quantum computing, for example, traffic planning and avoiding traffic, drug development, simulating climate change, and protecting information by using new encryption methods.

The collaboration effort between the JKU and FH OÖ will also strengthen advancements in Upper Austria as a location of information security. The Upper Austrian government supports the collaboration between the two universities as part of a joint dissertation program at the University of Applied Sciences in Upper Austria and the LIT Secure and Correct Systems Lab at the JKU: over the next three years they are funding a dissertation position successfully filled by Thomas Grurl (28) from Linz.

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