Mathematician Zdeněk Dvořák: Inspired by the real world

Theoretical mathematics inspired by the real world

“Most of my work still takes place on paper,” says theoretical mathematician Zdeněk Dvořák from the Computer Science Institute of Charles University. He focuses on combinatorics, graph theory, and theoretical informatics, and he received the ERC CZ Consolidator Grant for his research.

“Being awarded the grant will allow me to focus on research and fund a postdoc and other doctoral students who will work on the project with me. Most importantly, it will allow me to continue in international cooperation,” the mathematician says. “We cooperate especially with **McGill University** in Montreal, Canada and the **National Institute of Informatics in Tokyo**. I was supposed to be leaving for Japan, however, due to the coronavirus this had to be postponed,” he adds. Dvořák obtained more than CZK 7 million for solving a project named Algorithms and complexity within and beyond bounded expansion. “It is a graph-theory project, which may be misleading for non-experts. A non-mathematician usually imagines a graph as a line, perhaps the exponential. Mathematicians imagine a graph as something which may be called a network. A computer network, a Facebook relation network, a road network, for example: some points interconnected by relations. What we are interested in, is solving problems occurring in these networks. To show it in an example – on social networks, we may study the patterns of relationships appearing there, and deduce certain qualities based

on that, such as: has this community appeared spontaneously, or was it purposely created by somebody? Studies of real networks open problems which we then want to solve also in abstract networks. And we can see that numerous problems cannot be solved effectively in an entirely abstract network," the mathematician explains.

This is why mathematicians invented the theory of bounded expansion. It may be explained as limiting the complexity of networks. Once again, they find inspiration in the real world: "Roads, for example, cannot intersect arbitrarily – there are rules and limitations in their use. At the same time, there are numerous imperfections and exceptions: bridges are a good example." Zdeněk Dvořák's research is purely theoretical: "The goal of the project is to find the hierarchy of qualitative network limitations – whether there is, for example, a certain geometrical structure that might be described." The entire approach is entirely new and unknown: "We do not know whether there actually is any related geometrical structure. If we succeed in finding it, it will give us new tools for solving pro-blems as well as inspiration for further research." The question about examples' possible practical use of solving these algorithms is one he finds slightly annoying. The reason? "Science should be done out of interest and curiosity. Practical use is, of course, important, but it shouldn't be the pri-mary motivation. These algorithms might help improve the efficiency of navigation – they might help in finding the required path quicker."

Cooperation is motivating

As a general rule, research teams in mathematics tend to be small, and many mathematicians work individually; Zdeněk Dvořák, however, prefers working with colleagues: "I am glad when a foreign colleague visits us, or when I am visiting somebody for a few weeks. It is great motivation – both in terms of different approaches and thus more ideas, and of performance. I would feel stupid in front of my colleague if I didn't get any idea after several hour's work," he laughs.

The work of theoretical mathematicians takes place in discussing ideas and solutions to problems and trying to apply the concepts and verifying whether their ideas are valid in the remaining time. They use computers, sometimes. "Ninety per cent of my work takes place on paper. Sometimes, we also use blackboards – ideas written there may be easily erased, and blackboards are great when you are working with somebody – but a pencil and paper are winners for me." Dvořák tries applying various principles that proved effective in other areas on solving problems. "From time to time I get an entirely unique idea. This happens, when I have been working for about two weeks on a problem, and then this new idea comes suddenly, when I am taking a walk, perhaps," he says.

Greater interaction is needed

The mathematician focuses on teaching and popularization, among other things: “We organize an informatics-oriented version of Mathematical Olympiad for high school students and also corre-spondence seminars of informatics,” he points out.

He got inspiration also during his postdoc stays in the USA and Canada: “The science itself is quite similar there. In our field we need no special equipment – a pencil and paper is used abroad as well as in the Czech Republic. What is interesting, is the way of teaching – university education is broa-der in the United States. Students may combine mathematics with such subjects as literature or theatre. I found that interesting.” After returning home, the thing he misses most is more intera-ction of students with teachers: “What I liked in the US was that the students were more active in their interaction and communication with tutors – they would have consultations. I tried introdu-cing it here in the Czech Republic, however, with less success,” he states.

Dvořák has been recognised on multiple occasions for his work and received the Neuron Prize for young scientists in 2011. However, the one he values the most is the European Prize in Combinatorics: “This prize is awarded to young promising scientists in the field of discrete mathematics, com-binatorics, and graph theory. I feel honoured that they saw me as promising at that time,” he admits.
In his leisure time, he enjoys reading sci-fi literature and doing the Japanese martial art Shinto Muso Ryu Jodo. “Jodo has several levels for me; it is, of course, a physical activity – I spend most of the time at work sitting, which means that exercise is a welcome change. But there is also a spiritual level, mental relaxation. I also like the fact that although I have been doing it for 15 years, there is still a lot to learn or improve.”
Japanese culture has been his interest for a long time: “I would say it is one of the few developed countries which is not a western-style one. The Japanese culture and mentality is completely diffe-rent. I enjoy discovering more about it and I love the Japanese landscape. Within two hours, you can get from a metropolis like Tokyo into the heart of intact nature. I love the contrast,” he says.

Zdeněk Dvořák, Ph.D., works at the **Computer Science Institute of Charles University** focusing on combinatorics, graph theory, and theoretical informatics. He spent two years as a postdoc at Georgia Institute of Technology in Atlanta, USA and Simon Fraser University in Vancouver, Canada. This year, he was awarded an ERC CZ grant for his project Algorithms and complexity within and beyond bounded expansion.

ERC Grant Information
ERC grants are awarded by the European Research Council and funded from the EU budget. These are very prestigious grants aimed at supporting excellence in science in all fields. A great em-phasis is on entirely new revolutionary ideas with the potential of influencing the given field sig-nificantly, of extending its boundaries, or even opening new perspectives of research.
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