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[TITLE]

Designing good solutions on many optimization problems with help of graph theory

[MAIN TEXT]

My main research interest is discrete mathematics—more precisely, graph theory and theoretical computer science.　The abstract graphs we study consist of lines and points. Although this structure might sound like it has nothing to do with the real world, it's actually used all around us. For example, the idea in graph theory is successfully applied to the frequency band assignments for mobile phones and the car navigation systems. Unfortunately, not many people study discrete math for practical applications, but I'm sure that our research helps develop network technology and some related problems in the real world.

Optimal routing for networks

When I started my research, I was just interested in Graph Theory from a mathematical point of view. The topic itself is mathematically very deep, but I wasn't aware of practical applications of this research. But when I got interested in Theoretical Computer Science, I came to know some mathematical method that has many applications in the real world. One such topic is a network. Suppose that some terminals are given in a network, and we want to connect these terminals to create routes for sending as many goods and as much information as possible. The problem is that we want to figure out whether or not it is possible to connect these terminals, and moreover, sometimes we want to connect specified terminals, and some other terminals must be contained in a different component.

The solution for just one pair of terminals is simple. But for multiple pairs of terminals, even if you could intuitively draw routes, it would be hard to prove mathematically that those routes would be optimal or suboptimal. In some cases, routes are hard to establish. One might guess that it would be hard to tell whether the route configuration is acceptable. But fortunately, some idea in graph theory may help settle these issues. This is my main research interest.

Reducing calculation processes by maximizing mathematical knowledge

In the above example, if there’s an area which is sufficiently far from terminals, then it might not affect the feasibility of our problem. Actually, if one could prove mathematically that it would not affect the feasibility at all, we could delete that area and perform our algorithm just for the remaining area. Actually, sometime this is true, and we can prove it from a mathematical point of view. In other words, in certain cases, by studying the structure of the input data, we can delete the areas that are not needed, and it may be possible to give optimal or very good solution. This idea is quite simple to execute, and the algorithm is easy (just need to find the “area” we discussed above). But the proof for the correctness is (very) hard, and we need a deep mathematical theory (mostly in graph theory). I have studied a profound graph theory, and my knowledge would help prove the correctness of this kind of problems.

Graph theory has a long history, but there are lots of new recent breakthroughs. For example, the “strong perfect graph conjecture”, which was proposed almost 50 years ago, was solved just recently. This theory is mathematically very intriguing, but it was motivated from research in information theory. It had been open for more than 50 years. A broad range of research activities requires the application of mathematical theory. My research interests lie in these areas too.

(Interviewed and summarized by Atsushi Saito)