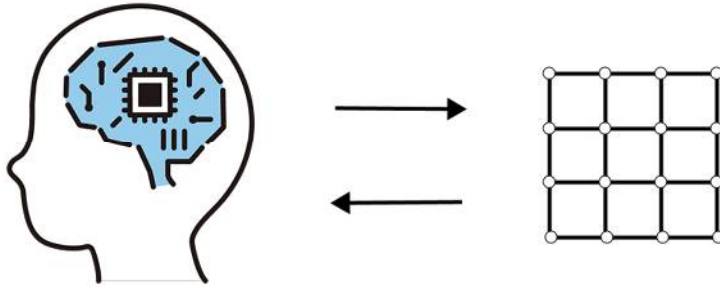


## The secret of Neural Networks: A Physics Perspective

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These days, the word "AI" is everywhere. You may have used AI tools like ChatGPT or Google Translate, or picture generation service. You might have seen news reports about AI beating a human champion in the board game Go. But what do you think of when you hear "AI"? Some people are very excited and want to use it for everything. Others are worried, thinking AI might steal our creative work or even become more powerful than humans.

So, how can we figure out what AI really is? To make good decisions about AI, we need a clear and accurate understanding of what it can and cannot do, and how it works. It's also important to think about how we can improve AI. Today's AI tools use a lot of electricity, while humans can perform similar tasks using much less energy.

I am now studying neural networks, a key part of modern AI, to help answer these questions. A neural network is a computer program that can learn from data. For example, if we show it many pictures of animals, it can learn to tell the difference between a cat and a dog. During this process, the network gradually changes how it calculates and makes decisions, improving its ability to give correct answers over time.

Despite being widely used, we still don't fully understand why neural networks work so well. This is mostly because their calculation process is too complex. That's where my research comes in. I use ideas from physics to study how neural networks learn.

In physics, we often describe very complicated systems—like gases made of an enormous number of tiny particles (around  $10^{23}$ )—using just a few simple values, such as temperature or pressure. This helps us understand the system without getting lost in all the details. I try to do something similar with neural networks: to build simple models that explain how they learn.

One topic I focus on is called neural scaling laws. These are rules discovered through observation that show how the performance of a neural network changes depending on its size, the amount of data it sees, and the computing power used. These relationships can often be described using just a few variables, something physics is very good at! If we understand these laws better, we can predict how well a neural network will perform and even design more efficient and powerful ones.

One reason I find this research so exciting is because of the amazing predictive power of neural networks. Once trained, they can do more than just remember what they were shown. They can make guesses about new things they have never seen before.

In real life, to make accurate predictions about unknown data, we need to understand the deeper structure of the problem. In science, such as physics, biology, and economics, researchers try to find patterns and mathematical laws that explain the world. These laws help us understand things we have never directly experienced.

I believe that by uncovering the hidden rules behind how neural networks learn and make predictions, we can find new ways to solve problems like we did in other scientific fields.

Another reason I find this research exciting is that there is still a lot of room for improvement. The big differences between the human brain and neural networks are energy use and flexibility. I hope that my research can help solve this problem. I'm also interested in applying ideas from neuroscience to improve AI. This wide range of approaches, combining physics, computer science, and brain science, makes the research even more exciting.

If I could advise my 12-year-old self, I would tell him not to get lost in superficial details, but to try to understand the principles behind them.

When I was younger, I believed that solving as many practice problems as possible was the key to understanding. This approach wasn't wrong, as working through many examples does help. However, I rarely thought about the deeper principles behind the problems.

Through my studies after entering university, I realized the importance of knowing the mechanism and was fascinated that physics can explain and predict a wide range of phenomena in the real world. For example, Newtonian mechanics, a basic theory in physics, can describe both the motion of a soccer ball and the movement of planets in space. This kind of deep explanation is both powerful and beautiful.

I wish I had discovered this kind of excitement earlier. Because this kind of deep understanding doesn't just apply to physics. It also applies to math, biology, and even subjects like history or classical literature. When I was in junior high school, I thought history and classical Japanese were just full of confusing details and lacked excitement. But now I realize that those subjects also have structure and logic. They're full of patterns and insights.

Grammar was checked using ChatGPT

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