Mathematicians Are Close to Building the Perfect Periodic Table of Shapes

The table will unlock a whole new wave of discoveries.

BY DARREN ORF PUBLISHED: OCT 16, 2023

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- Fano varieties are known as the basic "atomic structure" of geometry, but are notoriously difficult to discover and organize.

- Scientists from the Imperial College of London have been attempting to build a "periodic table of shapes" filled with these Fano varieties for more than a decade.
- In a new study, these scientists—as well as scientists from the University of Nottingham—have turned to AI and machine learning to help form this new periodic table.

Just as molecules can be broken down into atoms, so too can mathematical shapes be broken down into more basic components. These components are known as Fano varieties—named after Italian mathematician Gino Fano—and understanding them can help mathematicians make major discoveries.

There's just one problem. Fano varieties are notoriously difficult to categorize.

That's what scientists at the Imperial College of London discovered when they set out to create a "periodic table of shapes" more than a decade ago. Similar to how elements are grouped together with like elements on the periodic table, this geometric table aims to group related Fano varieties together. Easier said than done.

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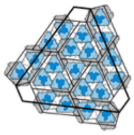

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So, the Imperial team—which also includes scientists from the University of Nottingham—turned to AI and machine learning to help speed up the process. The results of this novel method were published in the journal *Nature Communications* in early September.

"Fano varieties are basic building blocks in geometry—they are 'atomic pieces' of mathematical shapes," the study reads. "Our results demonstrate that machine learning can pick out structure from complex mathematical data in situations where we lack theoretical understanding. They also give positive evidence for the conjecture that the quantum period of a Fano variety determines that variety."

These shapes are not your average, run-of-the-mill parallelograms—rather, they are complex shapes that are more spherical and without hard edges. These shapes can be described by differential equations, and if they meet certain unique "flow pattern" criteria, they're considered "atoms." However, multiple occurrences of these patterns means that the shape can be further broken down into smaller components.

Fano discovered the first of these "atomic" shapes back in the 1930s. More have been discovered since, but so far, they lack any organizing principle. Once categorized in a periodic table defined by a shape's unique quantum period, gaps could help tell mathematicians where new shapes could be discovered (much like what the periodic table does for chemists and physicists).

"For mathematicians, the key step is working out what the pattern is in a given problem," study co-author Alexander Kasprzyk, a professor at the University of Nottingham, said in a press statement. "This can be very difficult, and some mathematical theories can take years to discover."

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Luckily, finding patterns in a large dataset is AI's specialty.

In the study, the team assigned a kind of "barcode"—the number for which was determined by the shape's features—to each shape. With 99 percent accuracy, the AI was able to discern the properties of these shapes from just the barcode alone, insinuating that grouping these shapes is a possibility. This has helped the team begin to form a periodic table of shapes by grouping similar geometric properties with one another.

In addition to being a helpful hand in crafting a periodic shape table, using AI in this way also has broader implications for mathematics as a whole. “This could be very broadly applicable, such that it could rapidly accelerate the pace at which maths discoveries are made,” PhD student and study co-author Sara Veneziale said in a press statement. “It’s like when computers were first used in maths research, or even calculators: it’s a step-change in the way we do maths. [sic]”

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Darren lives in Portland, has a cat, and writes/edits about sci-fi and how our world works. You can find his previous stuff at Gizmodo and Paste if you look hard enough.

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