Nature Reviews Physics | https://doi.org/10.1038/s42254-020-0149-9 | Published online 21 January 2020

MACHINE LEARNING

(Re)discovering physics

At the end of last year, the number of papers posted on *arXiv* every month had surpassed 13,000. No wonder it has become impossible for scientists to keep up with all the current work in their own fields, let alone in other areas. Yet, breakthroughs in science often come from combining existing concepts in new ways, or finding connections between seemingly unrelated topics. Writing in *Proceedings of the National Academy of Sciences of the USA*, Mario Krenn and Anton Zeilinger introduce a semantic network (SemNet) of concepts in quantum physics that can map out the existing body of knowledge and use it to suggest future lines of research.

Credit: agefotostock / Alamy Stock Photo

SemNet consists of nodes, which refer to concepts such as 'photon antibunching' or 'neutron radiation', and edges, which are formed when two concepts appear in the same article. These edges include instances of mathematical tools used to investigate quantum systems or insights from a technique leading to conclusions about a new property. Information drawn from 750,000 physics articles published 1919–2017, leads to a network with 6,368 vertices and 1.7 million edges. The network is used to identify emerging topics, such as the rapid growth of interest in graphene post-2005, and using subsets of historical data, could also accurately predict new emerging topics.

A promising application of this network lies in its potential insights for individual researchers. Using data from author lists, SemNet can learn about the expertise and interests of scientists, by identifying which particular concepts they have investigated, relative to the interest in those concepts in general. The network can then suggest pairs of concepts that have not yet been studied together — but may have promising connections — that are relevant to the existing work of specific authors.

Historically such connections have often happened by accident but perhaps machine learning can provide a more intentional approach towards thinking of new research directions. Furthermore, it might go even further and 'discover' physical concepts from experimental data. In a separate study, published in *Physical Review Letters*, Raban Iten and colleagues present a neural network (SciNet) into which they input various types of experimental data. When given a time series of the positions of the Sun and the Moon, as seen from Earth, SciNet deduced Copernicus' heliocentric model of the solar system.

Although it is still early days, machine learning has the potential to help physicists uncover new ideas and the links between them.

Ankita Anirban

ORIGINAL ARTICLE Krenn, M. & Zeilinger, A. Predicting research trends with semantic and neural networks with an application in quantum physics. *Proc. Natl. Acad. Sci. USA* https://doi.org/10.1073/pnas.1914370116 (2020)

RELATED ARTICLE Iten, R. et al. Discovering physical concepts with neural networks. *Phys. Rev. Lett.* **124**, 010508 (2020)