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Speeding up machine learning by means of light

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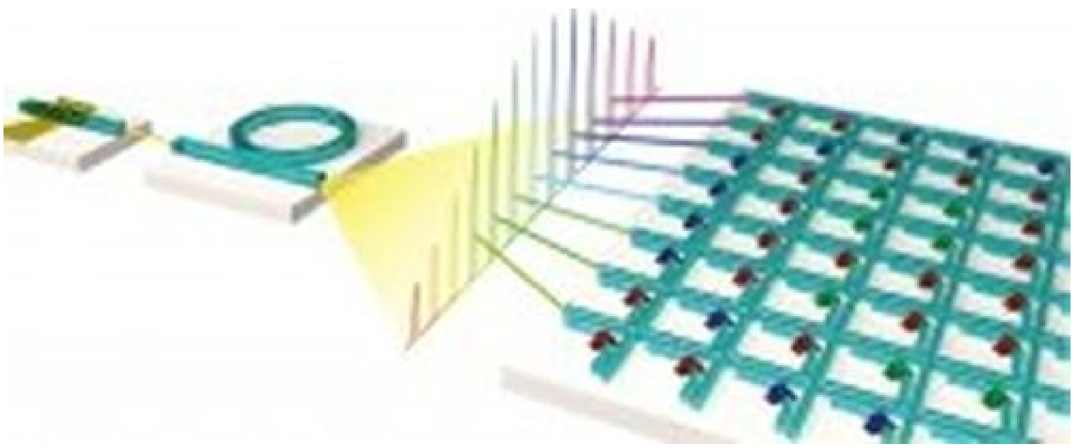

An international team of researchers has developed a next-generation computer accelerator chip that processes data using light rather than electronics. Credit: University of Exeter

Scientists have developed a pioneering new approach that will rapidly speed up machine learning—using light.

An international team of researchers—from the Universities of Münster, Oxford, Exeter, Pittsburgh, École Polytechnique Fédérale (EPFL) and IBM Research Zurich—has developed a next-generation computer accelerator chip that processes data using light rather than electronics.

The results are published in the leading scientific journal *Nature* on Wednesday, January 6th.

Professor C. David Wright of the University of Exeter, who leads the EU project Fun-COMP which funded this work said: "Conventional computer chips are based on electronic data transfer and are comparatively slow, but light-based processors—such as that developed in our work—enable complex mathematical tasks to be processed at speeds hundreds or even thousands of times faster, and with hugely reduced energy consumption."

The team of researchers, led by Prof. Wolfram Pernice from the Institute of Physics and the Center for Soft Nanoscience at the University of Münster, combined integrated photonic devices with phase-change materials (PCMs) to deliver super-fast, energy-efficient matrix-vector (MV) multiplications.

MV multiplications lie at the heart of modern computing—from AI to machine learning and neural network processing—and the imperative to carry out such calculations at ever-increasing speeds, but with ever-decreasing energy consumption, is driving the development of a whole new class of processor chips, so-called tensor processing units (TPUs).

The team developed a new type of photonic TPU—one capable of carrying out multiple MV multiplications simultaneously and in parallel, using a chip-based frequency comb as a light source, along with wavelength-division-multiplexing.

The matrix elements were stored using PCMs—the same material currently used for re-writable DVD and BluRay optical discs—making it possible to preserve matrix states without the need for an energy supply.

In their experiments, the team used their photonic TPU in a so-called convolutional neural network for the recognition of handwritten numbers and for image filtering. "Our study is the first to apply frequency combs in the field of artificial neural networks," says Prof. Wolfram Pernice.

"Our results could have a wide range of applications," explained Prof. Harish Bhaskaran from the University of Oxford, a key member of the team: "A photonic TPU could quickly and efficiently process huge data sets used for medical diagnoses, such as those from CT, MRI and PET scanners," he continued.

Further applications could also be found in self-driving vehicles—which depend on fast, rapid evaluation of data from multiple sensors—as well as for the provision of IT infrastructure such as cloud computing.

More information: J. Feldmann et al. Parallel convolutional processing using an integrated photonic tensor core, *Nature* (2021). DOI: 10.1038/s41586-020-03070-1

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