Is deep learning a necessary ingredient for artificial intelligence?

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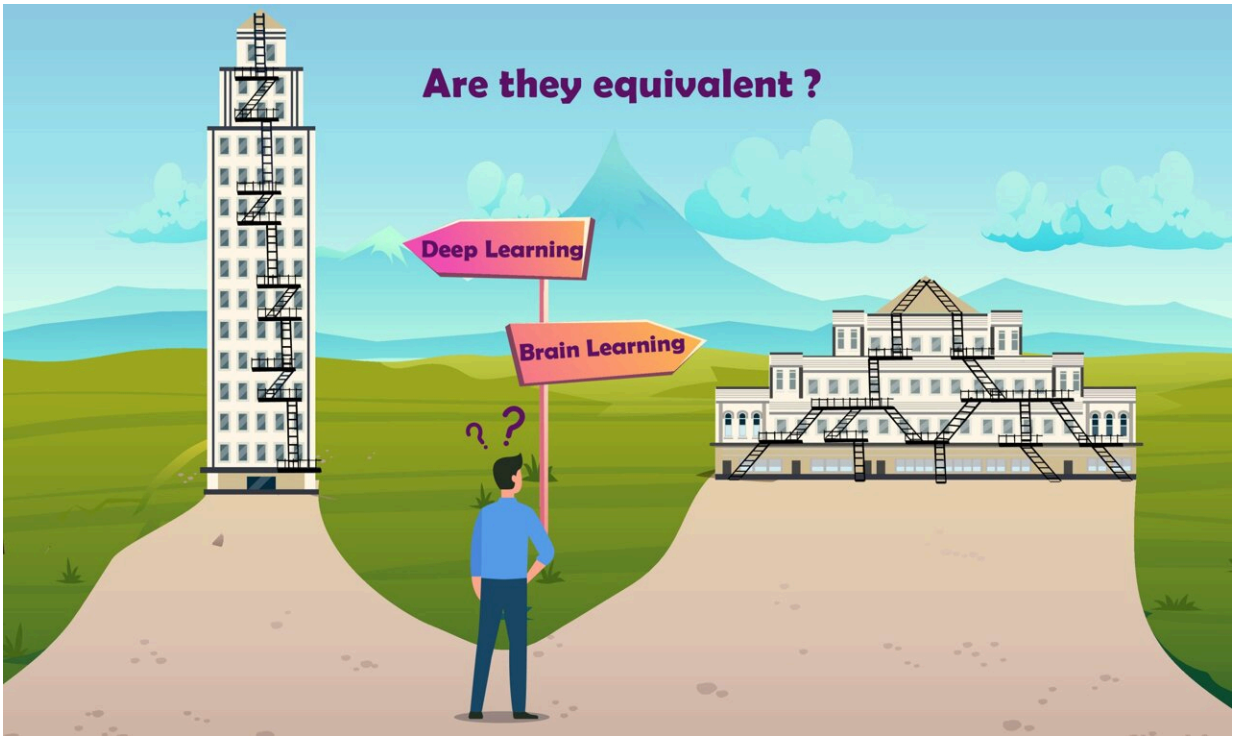

Scheme of Deep Machine Learning consisting of many layers (left) vs. Shallow Brain Learning consisting of a few layers with enlarged width (right). Credit: Prof. Ido Kanter, Bar-Ilan University

The earliest artificial neural network, the Perceptron, was introduced approximately 65 years ago and consisted of just one layer. However, to address solutions for more complex classification tasks, more advanced

neural network architectures consisting of numerous feedforward (consecutive) layers were later introduced. This is the essential component of the current implementation of deep learning algorithms. It improves the performance of analytical and physical tasks without human intervention, and lies behind everyday automation products such as the emerging technologies for self-driving cars and autonomous chat bots.

The key question driving new research published today in *Scientific Reports* is whether efficient learning of non-trivial classification tasks can be achieved using brain-inspired shallow feedforward networks, while potentially requiring less computational complexity.

"A positive answer questions the need for deep learning architectures, and might direct the development of unique hardware for the efficient and fast implementation of shallow learning," said Prof. Ido Kanter, of Bar-Ilan's Department of Physics and Gonda (Goldschmied) Multidisciplinary Brain Research Center, who led the research. "Additionally, it would demonstrate how brain-inspired shallow learning has advanced computational capability with reduced complexity and energy consumption."

"We've shown that efficient learning on an artificial shallow architecture can achieve the same classification success rates that previously were achieved by deep learning architectures consisting of many layers and filters, but with less computational complexity," said Yarden Tzach, a Ph.D. student and contributor to this work. "However, the efficient realization of shallow architectures requires a shift in the properties of advanced GPU technology, and future dedicated hardware developments," he added.

The efficient learning on brain-inspired shallow architectures goes hand in hand with efficient dendritic tree learning which is based on previous

experimental research by Prof. Kanter on sub-dendritic adaptation using neuronal cultures, together with other anisotropic properties of neurons, like different spike waveforms, refractory periods and maximal transmission rates.

For years brain dynamics and machine learning development were researched independently; however, brain dynamics has recently been revealed as a source for new types of efficient artificial intelligence.

More information: Efficient shallow learning as an alternative to deep learning, *Scientific Reports* (2023). DOI: 10.1038/s41598-023-32559-8. www.nature.com/articles/s41598-023-32559-8

Provided by Bar-Ilan University