



An Ambassador for Neural Networks

David Alan Grier, Djanghe, LLC

Neural networks were never a new part of computing, but at one point they needed a dedicated ambassador to move them into computing practice.

We should not be surprised to find a tutorial on artificial neural networks in the list of *Computer's* most influential articles. Neural networks are now a common subject in computer science, and they have been taught to two or three generations of undergraduates. They would be an obvious topic for a clear and well-organized article, such as the one written by Anil K. Jain, Jianchang Mao, and K.M. Mohiuddin. This article ranks number 30 on the list of the most influential articles that have been published by *Computer*. It has 5,128 downloads and 740 citations.

Yet, there are several surprises in the article that help us understand both its position in the body of knowledge

and the role of *Computer* in building that body of knowledge. Perhaps the prominent surprise is that the article has never been cited by another article in *Computer*, the publication that brought it to the field.

This fact, which seems anomalous in the technical literature, leads us to consider the role and position of artificial neural nets in the field of computing. They actually have a long and storied history that dates to the very first days of the field. You can find them, in a primitive form, in John von Neuman's 1945 technical report,

ARTICLE FACTS

- » Article: "Artificial Neural Networks: A Tutorial"
- » Authors: A.K. Jain, J. Mao, and K.M. Mohiuddin
- » Citation: *Computer*, vol. 29, no. 3, pp. 31–44, March 1996
- » Computer influence rank: #30 with 5,128 downloads and 740 citations



“First Draft Report on the EDVAC.”¹ We generally remember this report as describing the structure that we now call the von Neuman Architecture, yet von Neuman drew on the work of Warren McCulloch and Walter Pitts to show the connection between the structure of the brain and mechanical computation.² He found the connection so compelling that he returned to this idea in his final work, *The Computer and The Brain*, which he prepared as the Silliman Memorial lecture on science for Yale University.³

Even with its connection to von Neuman’s work, artificial neural networks would not be a major technology for the artificial intelligence research of the 1950s and 1960s. At that time, there was no good theory that described the properties of these networks or how they operated. Instead, researchers focused their attention on symbolic or search-based systems. Familiar examples include Newell, Saw, and Simon’s General Problem Solver;⁴ Simon and Feigenbaum’s Elementary Perceiver and Memorizer;⁵ Shortliffe’s Expert System Mycin;⁶ and Greenblatt’s chess program.⁷

Many writers claim that the work of Marvin Minsky and Seymour Papert pushed neural networks out of computer science temporarily, but this point of view misrepresents the work of Minsky and Papert and simplifies a complex period in the history of computing. In their 1969 book, *Perceptrons*, the two authors started to build a theoretical model for neural nets by looking at a perceptron, a linearized version of a general neuron. In their book, Minsky and Papert⁸ demonstrated the limitations of a single perceptron but, at the same time, laid the foundation for a general theory of neural networks and an important result. This result stated that as a tool for approximating functions, networks of perceptrons could approximate any mathematical function to any degree of accuracy.⁹

Building a theory of neural networks also included the work of re-conceptualizing these computing structures and placing them in a new context. By the mid-1970s, researchers had recognized that neural networks were classifiers and had properties that were similar to existing classification algorithms, such as those derived from statistical models. Paul Werbos was one of the great pioneers of this concept, and his great contribution was the back propagation algorithm.

times by a broad collection of journals. (Other citation sources give a number that is almost four times larger.) It has been cited by articles on medicine, tomography, communications, agriculture, chemistry, and encryption. It is repeatedly cited by articles that are presenting new classification algorithms.

Perhaps somewhat unusual for a *Computer* article, it is primarily cited by conference papers. Well over half of the cites in *IEEE Xplore* are to such papers,

The article, as Jain described it, was a simple, straightforward article “to inform readers with little or no knowledge of neural networks and help them understand detailed technical publications.”

Starting with his 1974 Ph.D. thesis, his work sparked a growing interest in neural nets and expanded the number of potential applications for them.¹⁰ In 1990, the IEEE created *IEEE Transactions on Neural Networks*, and six years later, the editors of *Computer* felt that it was time to do a special issue on the topic. They asked our authors to prepare a tutorial for that issue. “My research interest,” wrote lead author Jain, “was primarily in the field of statistical pattern recognition and data clustering.” As neural nets became more important, he “was fascinated by their generalization and feature extraction abilities.”

The article, as Jain described it, was a simple, straightforward article “to inform readers with little or no knowledge of neural networks and help them understand detailed technical publications.” As a result, it has become a classic in the field. It is regularly cited by papers that are first efforts to apply neural nets or machine learning to new applications. According to *IEEE Xplore*, it has been cited 740

which suggests its role as a tutorial. It has explained neural nets not only to researchers who work in computer science but also to those work in other fields. This role is suggested by the number of citations, which declined slightly around 2010 as deep networks and machine learning were becoming common in computer science but rose again as these technologies moved into other fields. Reinforcing this conclusion is the fact that the article is cited far more frequently by periodicals published by outside organizations than those published by the IEEE Computer Society. In fact, *IEEE Xplore* lists no citations of this article by any IEEE Computer Society magazine.

In the body of computing literature, this article by Jain, Mao, and Mohiuddin is an ambassador that takes the work of our members and delivers it to other technical communities around the world.

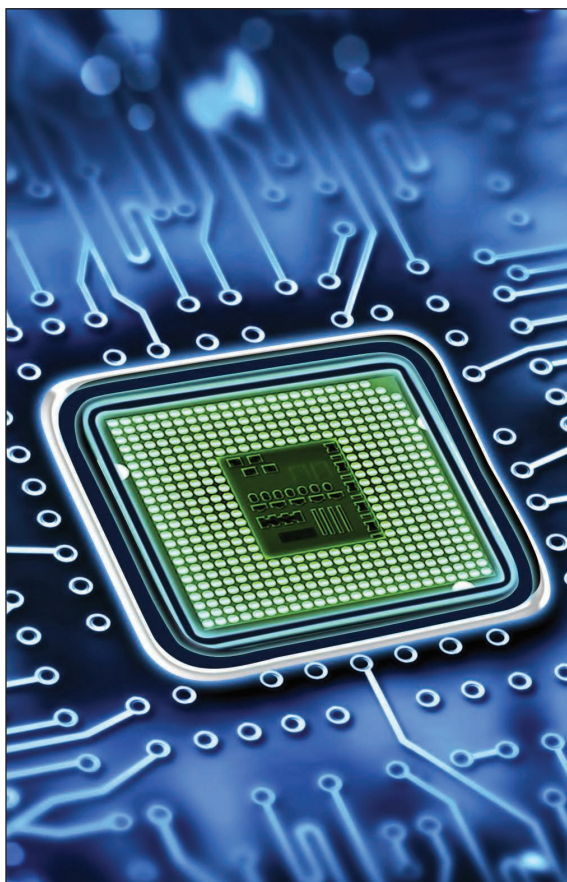
It has needed no other recognition in *Computer*.

Until now. ■

REFERENCES

1. J. von Neumann, "First draft report on the EDVAC," *IEEE Ann. Hist. Comput.*, vol. 15, no. 4, pp. 27–75, 1993. doi: 10.1109/85.238389.
2. J. von Neumann, *The Computer and the Brain*. New Haven, CT: Yale Univ. Press, 1958.
3. W. S. McCulloch and W. Pitts, "A logical calculus of ideas immanent in nervous activity," *Bull. Math. Biophys.*, vol. 5, pp. 115–133, Dec. 1943. doi: 10.1007/BF02478259.
4. A. Newell, J. C. Shaw, and H. Simon, "Report on a general problem-solving program for a computer," in *Proc. Int. Conf. Information Processing*, 1960, pp. 256–264.
5. E. Feigenbaum, "The simulation of verbal learning behavior," in *Proc. IRE-AIEE-ACM '61 (Western)*, 1961, pp. 121–132. doi: 10.1145/1460690.1460704.
6. E. Shortliffe, "A rule-based computer program for advising physicians regarding antimicrobial therapy selection," in *Proc. Annual ACM Conf. (ACM '74)*, Jan. 1974, vol. 2, p. 739. doi: 10.1145/1408800.1408906.
7. R. Greenblatt, D. Eastlake, and S. Crocker, "The Greenblatt Chess Program," in *Proc. Fall Joint Computer Conf.*, 1967, pp. 801–810. doi: 10.1145/1465611.1465715.
8. M. Minsky and S. Papert, *Perceptrons: An Introduction to Computational Geometry*. Cambridge, MA: MIT Press, 1969.
9. G. Cybenko, "Approximations by superpositions of sigmoidal functions," *Math. Control, Signals, Syst.*, vol. 2, no. 4, pp. 303–314, 1989. doi: 10.1007/BF02551274.
10. P. Werbos, "Beyond regression: New tools for prediction and analysis in the behavioral sciences," Ph.D. dissertation, Dept. of Applied Mathematics, Harvard Univ., Cambridge, MA, 1974.

DAVID ALAN GRIER is a principal with Djaghe, LLC. He is a Fellow of the IEEE. Contact him at grier@gwu.edu.



IEEE TRANSACTIONS ON

COMPUTERS

Call for Papers: IEEE Transactions on Computers

Publish your work in the IEEE Computer Society's flagship journal, *IEEE Transactions on Computers*. The journal seeks papers on everything from computer architecture and software systems to machine learning and quantum computing.

Learn about calls for papers
and submission details at
www.computer.org/tc.

Digital Object Identifier 10.1109/MC.2020.2993517

