PLENARY TALK

Seeing the Sky: New Quantum Hardware Offers Millions-Fold More Power

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Abstract:
Humanity is now at the early beginning of the deep learning revolution in AI, started by NSF research grant 0835878 to Andrew Ng, Ed Boyden, Yann LeCun and Yang Dan in 2008. (For details, see werbos.com/Mind.htm.) The Science News story "Probing Human Mind and Future Infrastructure Systems, October 3, 2008, described that grant, and the new direction in AI which gave rise to the COPN program -- cognitive optimization and prediction. Werbos, P. J., & Davis, J. J. (2016). Regular cycles of forward and backward signal propagation in prefrontal cortex and in consciousness, in Frontiers in systems neuroscience, 10, 97. went on to show how new neural network designs based on cognitive prediction and cognitive optimization (compatible with hardware like GPUs used in early work by LeCun and now by nVidia) can replicate and explain the higher levels of intelligence we see in mammal brains.
But these designs all rested on minimizing a loss or value function at the bottom, which is usually a highly nonconvex optimization problem. Likewise, the highest resolution technology for "seeing the sky" (see QuATh and ICI, by Werbos and Hyland, posted by USPTO in the patent for thermal quantum Annealing, tQuA), leads to such a nonconvex minimization task. Seeing the sky better is at the core of many urgent challenges, from warning people of attacks from the sky to better understanding nuclear forces in our galaxy (like dark matter but with high resolution). That patent displays a new type of quantum computing, radically different from the quantum Turing machines known to most experts; it uses quantum superposition to solve these minimization problems, and, unlike the core of the DWave architecture, uses true physical annealing to optimize N continuous complex variables. Considerable evidence now demonstrates the generality of the method, which does for quantum learning what deep learning did to improve capabilities over classical Turing machines.

Biodata:

Paul J. Werbos holds four degrees from Harvard and the London School of Economics in: (1) economics; (2) international political systems, emphasizing European economic institutions; (3) applied mathematics, with a major in quantum physics and a minor in decision and control; (4) applied mathematics, towards an interdisciplinary Ph.D. thesis. Prior to that, during high school, he obtained an FCC First Class Commercial Radiotelephone License, and took undergraduate and graduate mathematics courses at Princeton and the University of Pennsylvania.

His 1974 Harvard thesis has been reprinted in its entirety, along with related papers, in his book The Roots of Backpropagation: From Ordered Derivatives to Neural Networks and Political Forecasting, Wiley 1994.

For about 4 years after the PhD, he taught courses at Maryland in quantitative methods and global futures, and performed research in intelligent systems for policy application, including an extension of the user-oriented software he had worked on at Harvard and MIT. Then for 9 years he worked at the Department of Energy evaluating and developing a wide range of energy forecasting models, combining the use of methods like backpropagation, econometric forecasting models, and technology assessment covering a wide range of technologies; as an example, his model of industrial energy demand, by industry and by State, was the leading econometric-style model reviewed by the Stanford U. Energy Modeling Forum study of industrial energy models from all sources.

From 1989 to 1996, he served as Program Director for Neuroengineering at NSF. He also initiated the SBIR topic 26 which emphasizes fuel-cell automobiles, for which he is Technical Coordinator. He is a member of the Learning and Intelligent Systems (LIS) coordinating committee, and participates in the Collaborative Research Initiation (CRI) interdisciplinary initiative coordinated by the IBN Division of NSF. He is also involved in major collaborative activities with NASA, relatively informal at present, involving activities like hypersonic flight, reconfigurable flight control, and space robotics. He has also performed other duties at NSF and outside NSF less relevant to current ECS funding topics. He has served as President of the International Neural Network Society, where he is still on the Governing Board. He also serves as a member of the IEEE Neural Networks Council.

Within the Knowledge Modeling and Computational Intelligence (KMCI) area, his main goal is to maximize the development and dissemination of step-by-step advances in systems design which will lead to an understanding and replication of the general kind of learning-based intelligence seen in the higher centers of the brain. Since the brain is mainly composed of neural networks, he has paid special attention to the strategic issues in developing that field – ranging from global issues of decision and control, through to critical but lower-level issues such as learning speed and the representation of uncertainty. On the other hand, he has also stressed the development of general purpose learning designs, in which neural networks can be replaced by other nonlinear distributed structures. He supports efforts to better understand and enhance "stability" in such learning systems – particularly when this is important to critical real-world applications; however, he would accept certain notions of chaos control, in which "stability" may refer to an acceptable region of state space rather than a desired point.

His personal research interests include: (1) the development of learning designs, as per the previous paragraph; (2) links to neuroscience and efforts to understand the human mind more deeply; (3) issues in the foundations of quantum theory, particularly related to solitons and PDE; (4) issues involving sustainable growth, with partial emphasis on the role of advanced technologies.