Physics, chemistry Nobels for AI break new ground

L ouis Bachelier, the French mathematician regarded as the pioneer of financial mathematics, presented his doctoral thesis on March 29, 1900, at Sorbonne University in Paris. A committee of eminent mathematicians of that time examining Bachelier did not believe that mathematical equations could describe the quirky world of financial markets. Nevertheless, putting aside their instincts, they observed that Bachelier's work "is somewhat removed from those which are normally dealt with by our applicants. His thesis is entitled 'Theory of Speculation' and focuses on the application of probability to the stock market. First, one may fear that the author had exaggerated the applicability of probability as is often done. Fortunately, this is not the case." It took five decades before Bachelier's work was recognised as a seminal piece of financial mathematics.

In a replay of the half-hearted acceptance of Bachelier's work, the recent Nobel Prize announcement was greeted with a flurry of reactions: Should machine learning and Artificial Intelligence (ML/AI) techniques deserve the physics and chemistry Nobel?

Breaking new ground, the 2024 Nobel prizes have recognised ML/AI tools developed over many decades. The physics prize was awarded jointly to John Hopfield and Geoffrey Hinton "for foundational discoveries and inventions that enable machine learning with artificial neural networks". Half the chemistry prize was jointly awarded to Demis Hassabis and John Jumper for protein structure prediction through the AI model AlphaFold2. Does developing techniques constitute the same gold standard for the Nobel as a fundamental discovery that advances scientific understanding?

By far, most Nobels were given for fundamental scientific discoveries, not necessarily for developing tools and techniques. Physics Nobel has so far been awarded to 226 scientists. Between 1995 and 2017, 26% of all Nobel prizes went to atomic and particle physics, and most of these were discoveries of fundamental nature. The 2013 prize for the discovery of Higgs boson (hyped as the God particle) recognised the insight into how particles acquire mass. Consider another example. In 1964, a Nobel Prize was given for the development of lasers, though the basic ideas were proposed in 1917. Today, from barcode scan-

MS Santhanam

ners to medical devices, the laser is a ubiquitous tool. Back then, the laser was not known for many practical applications except spectroscopy, and no one anticipated its extraordinary commercial value. For the 1964 Nobel Committee, the clincher was the practical demonstration of stimulated emission and amplification, the core ideas behind lasers.

Against this backdrop, the 2024 Nobel for AI appears to tread a new path. The research behind the 2024 Physics Nobel Prize had its origins in the Ising model proposed in the 1920s by Wilhelm Lenz and Ernst Ising. This model captures the emergence of ferromagnetism in a collection of atoms whose internal angular momentum (called spins) interact with one another. Remarkably, with some important modifications, this model can be adapted as an algorithm for associative memory, a key ingredient for any learning process. After all, humans learn aided by associative memory — remembering things by association.

We instinctively remember a mango or a flower by its characteristic smell. Hopfield created an algorithm for addressable memory to store and retrieve content (as it happens in the brain) by repurposing a physics model as a neural network. Geoffrey Hinton advanced this framework even further by extensively borrowing from the central principles of statistical physics. His algorithm Boltzmann machine, named after the 19th century Austrian physicist Ludwig Boltzmann, employs the energy concept to characterise a neural network. Variants of the Boltzmann machine are now part of the arsenal of ML/AI practitioners to solve speech prediction to classification problems. Since the 1980s, these ideas with their physics underpinnings have revived the research directions of ML/AI.

The Physics Nobel Prize of 2024 might be a cautious first step towards making the Nobel respond to the science and research practices of this century. The choice suggests that the cultural ideas of what constitutes physics require revision. At another level, it reminds us that basic science advances technology, and must be encouraged. Thanks to the embedded ML/AL in our devices, this invisible science is now part of our daily lives.

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