New AI Models and Scientific Education

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Large language models (LLMs) use words and word fragments as input tokens for training the foundational models at the heart of generative AI tools such as ChatGPT, Gemini, and Claude. In addition to LLMs, new models are emerging that use different input tokens, such as historical weather data, fragments of animal sounds, and fundamental physics data.

Using these input tokens permits the construction and use of AI models to explore the natural world in ways similar to traditional experimentation and observation—methods that humans have used in scientific discovery for centuries. Together with theory and mathematical models, AI-driven approaches enable us to understand complex systems, providing faster, better, and more cost-effective insights than before.

Examples include:
Weather Prediction: One application in the news recently is weather prediction[1]. Traditional weather models rely heavily on mathematical equations and computationally intensive simulations. In contrast, AI models can process decades of historical weather data in a training phase and then be used repeatedly to quickly predict weather patterns with remarkable accuracy. These models outperform traditional methods in many practical uses with significantly lower computational costs, making advanced forecasting more accessible.

Animal Communication: AI is being used to gain insight into animal communication[2]. Recent work with whales, for instance, has revealed patterns in their sound-based interactions. In addition to understanding whale communications, it appears that whales across different ocean regions use a standard "vocabulary" but express themselves with regional dialects—similar to how a Bostonian accent differs from a Texan one. Worth noting in this case is that decision trees, a more straightforward form of AI algorithm, can be used successfully instead of using neural networks that provide advances in other areas.

Complex Systems: In fields where behavior is mathematically complex, AI approaches can learn from fundamental physics principles or from high-fidelity simulations that provide results across a

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1 *Probabilistic weather forecasting with machine learning,* https://www.nature.com/articles/s41586-024-08252-9
2 *AI decodes the calls of the wild,* https://www.nature.com/immersive/d41586-024-04050-5/index.html

range of parameter values[3]. Systems that evolve in unpredictable ways—such as the movement of particles in a fluid or the dynamics of ecosystems—can be modeled more effectively using AI. These approaches are faster and more reliable and enable researchers to tackle previously intractable problems.

Broader Use Cases: When I think of how to use AI in scientific environments, I like to think of a person sitting on a busy street corner observing day after day the activities of the people, cars, bikes, buses, etc., and then, eventually, being able to predict what will happen next base on synthesizing these observations to understand the fundamental system components and their interactions. New AI foundational models can help detect these components and interactions for understanding and prediction in many situations.

Implications for Education and Research

As these new AI methods become integral to scientific inquiry, their influence on education and research will likely emerge. While students may not yet encounter AI approaches in standard classroom curricula, these techniques seem likely to become a core element of research activities. Introducing fundamental AI concepts in experimental and observational sciences could prepare students for a future where AI is an important tool for discovery.

In some cases, the machine learning models are simple to understand. For example, decision trees are conceptually intuitive and can be helpful. In fact, in the *AI decodes the calls of the wild* article mentioned above, random forest algorithms, which are based on decision trees, provide a reasonable and transparent approach to identifying patterns in animal sounds.

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[3] *Generative learning for forecasting the dynamics of high-dimensional complex systems,* https://www.nature.com/articles/s41467-024-53165-w.pdf