NOBEL PRIZE IN PHYSICS - AWARDS

NEWS: The **2024 Nobel Prize in Physics** has been awarded by the **Royal Swedish Academy of Sciences** to **John J. Hopfield and Geoffrey E. Hinton,** two pioneers whose groundbreaking work laid the foundation for **modern artificial neural networks (ANNs) and machine learning (ML).**

- Their work has had profound implications for various fields, from physics to biology, finance, medicine and chat **Artificial Intelligence (AI)** apps, including **OpenAI's ChatGPT (Generative Pre-trained Transformer).**

WHAT'S IN THE NEWS?

What is the Contribution of John Hopfield?

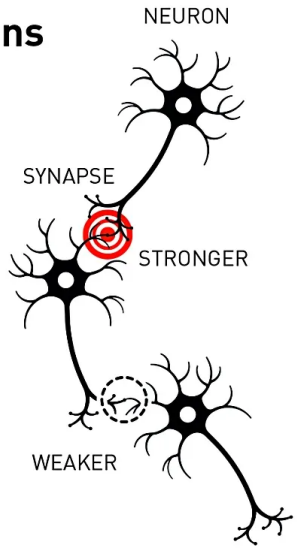
- **Hopfield Network:** John Hopfield, is best known for creating the **Hopfield network, a type of recurrent neural network (RNN)** that has been foundational in ANN and AI.
    - Developed in the 1980s, the Hopfield network is designed to store simple **binary patterns (0s and 1s)** across a network of artificial nodes (artificial neurons).
    - A key feature of the network is **associative memory,** which allows it to **retrieve complete information from incomplete or distorted inputs** (similar to how the human brain recalls memories when triggered by familiar sensations, like a scent).
    - The Hopfield network, based on **Hebbian learning** (a concept in neuropsychology where repeated interactions between neurons strengthen their connections).
        - By drawing parallels to atomic behavior, Hopfield used statistical physics to make the network perform **pattern recognition and noise reduction** by minimising energy states, a breakthrough in advancing neural networks and AI by mimicking biological brain functions.
- **Impact:** Hopfield's model system has been used to solve **computational tasks, complete patterns, and improve image processing.**

What is the Contribution of Geoffrey Hinton?

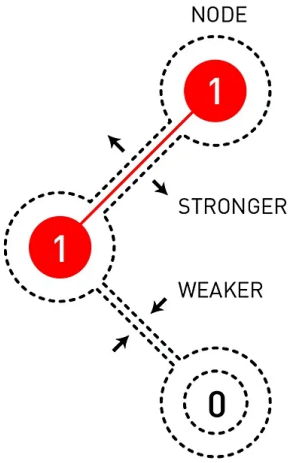
- **Restricted Boltzmann Machines (RBMs):** Building on Hopfield's work, in the 2000s, Hinton developed a learning algorithm for **Restricted Boltzmann Machines (RBMs),** which enabled deep learning by stacking multiple layers of neurons.
    - The RBMs could learn from **examples rather than explicit instructions.** This was revolutionary because it allowed the machine to recognize new patterns based on similarities with previously learned data.
    - The Boltzmann machine could recognize categories it had never encountered if they matched learned patterns.
- **Applications:** Hinton's work has led to breakthroughs in numerous fields, from healthcare diagnostics to financial modeling and even AI technologies like **chatbots.** \

Natural and artificial neurons

The brain's neural network is built from living cells, neurons, with advanced internal machinery. They can send signals to each other through the synapses. When we learn things, the connections between some neurons gets stronger, while others get weaker.



Artificial neural networks are built from nodes that are coded with a value. The nodes are connected to each other and, when the network is trained, the connections between nodes that are active at the same time get stronger, otherwise they get weaker.



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The Nobel Prize in Physics 2023 was awarded to **Anne L'Huillier, Pierre Agostini, and Ferenc Krausz** for their work in **attophysics (**focuses on generating and utilising extremely short light pulses to examine fast processes, particularly those involving electrons**)**.

What are Artificial Neural Networks (ANNs)?

About: ANNs are inspired by the structure of the brain, where **biological neurons** are interconnected to perform complex tasks. In ANNs, **artificial neurons (nodes)** process information collectively, allowing data to flow through the system, similar to brain **synapses.**

Common Architectures of ANNs:

- **Recurrent Neural Networks (RNNs):** It is trained on **sequential or time series data** to create a **machine learning (ML) model** that can make sequential predictions or conclusions based on sequential inputs.
- **Convolutional Neural Networks (CNNs):** Designed for **grid-like data** (e.g., images), CNNs use three-dimensional data for image classification and object recognition tasks.
- **Feedforward Neural Networks:** The simplest architecture, where information flows in one direction from input to output with fully connected layers.
    - It is simpler than recurrent and convolutional neural networks.
- **Autoencoders:** Used for unsupervised learning, they take input data, compress it to keep only the most important parts, and then rebuild the original data from this compressed version.
- **Generative Adversarial Networks (GANs):** They are a powerful type of neural network used for unsupervised learning. They consist of **two**

networks: a **generator,** which creates fake data, and a **discriminator,** which distinguishes between real and fake data.

- Through this adversarial training (a machine learning technique that helps models become more robust), GANs produce realistic, high-quality samples.
- They are versatile AI tools widely used in image synthesis, style transfer, and text-to-image synthesis, revolutionising generative modelling.

Source: https://www.thehindu.com/sci-tech/science/nobel-prize-in-physics-2024-winners-john-hopfield-geoffrey-e-hinton/article68732003.ece