



INFO 7375 - Neural Networks & AI

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Submitted By:

Abdul Haseeb Khan
NUID: 002844724
khan.abdulh@northeastern.edu

How does diffusion model work?

A diffusion model is a type of generative AI that creates high-quality data, such as images, by learning to reverse a process of gradual degradation. It works through two main phases: a forward process and a reverse process. In the forward process (diffusion), the model systematically adds random Gaussian noise to a piece of training data (like an image) over many steps until it becomes unrecognizable static or pure noise. The model's key task is the reverse process: it learns to predict and remove the noise step-by-step, effectively reconstructing a coherent image from random chaos. When generating new content, the model starts with pure random noise and iteratively "denoises" it using the patterns it learned during training to reveal a brand-new, high-fidelity image.

What is Artificial General Intelligence (AGI)?

Artificial General Intelligence (AGI), sometimes called "strong AI" or human-level AI, is a theoretical form of artificial intelligence that possesses the ability to understand, learn, and apply knowledge across a wide variety of tasks, much like a human being. Unlike current "narrow AI" (ANI), which is designed for specific tasks (like playing chess or recognizing faces) and struggles outside its training, AGI would be capable of generalization. It would have the capacity for common sense, reasoning, creativity, and the ability to transfer skills from one domain to another without needing to be explicitly reprogrammed or retrained for every new problem.

Describe the Turing test on AGI

The Turing Test, originally proposed by Alan Turing in 1950 as the "imitation game," is a behavioral test designed to assess whether a machine exhibits intelligent behavior indistinguishable from that of a human. In the standard setup, a human evaluator engages in a natural language conversation (text-only) with two hidden partners: one human and one machine. If the evaluator cannot reliably distinguish which is which based on their responses, the machine is said to have passed the test. For AGI, the Turing Test is often viewed as a benchmark for verifying human-level cognitive flexibility, as passing it requires not just linguistic fluency but also reasoning, humor, deception, and broad world knowledge. However, modern critics argue it may only test a machine's ability to mimic human conversation rather than proving true understanding or consciousness.

What is the Hopfield network and how does it work?

A Hopfield network is a type of recurrent neural network (RNN) that serves as a content-addressable memory system (associative memory). Invented by John Hopfield in 1982, it consists of a single layer of neurons that are fully connected to each other (except for self-connections) with symmetric weights. It works by storing patterns as stable states or "energy minima" within the network's energy landscape. When the network is presented with a distorted or partial version of a stored pattern, the neurons iteratively update their states based on the input from their neighbors until the network

settles into the closest stored pattern (the minimum energy state). This allows it to "remember" and reconstruct complete data from noisy or incomplete inputs.

Describe the refractory neural model.

The refractory neural model describes a biological constraint in neurons (and artificial spiking neural networks) where a neuron cannot fire immediately after generating an action potential (spike). This period of non-responsiveness is called the "refractory period" and has two phases: the **absolute refractory period**, during which it is impossible for the neuron to fire again regardless of the stimulus strength because its ion channels are inactivated; and the **relative refractory period**, where the neuron can fire but requires a much stronger stimulus than usual. In computational modeling, this mechanism is crucial for regulating the firing rate of neurons, preventing over-excitation (uncontrolled rapid firing), and ensuring that signals propagate in only one direction.