Synapse – ML – Task 3.2

**Task 3.2 -1**

(Q) Imagine using a random prompt like "a cat riding a bicycle on Mars" and seeing an AI generate an image that matches your description perfectly. This is made possible by using advanced models like DALL-E, which use various machine learning techniques, including the diffusion processes. For this task, explain what basic diffusion is, how it works, and why it is used in generating such impressive output.

Diffusion

Diffusion models are classified as Generative models i.e. they are used to generate a data similar to that which they are trained on. They have revolutionized how we create and manipulate digital content. Diffusion models currently produce top image quality.

Working:

Consider the **example** of a drop of paint being added to a glass of water. Though the red paint is initially concentrated at certain points in the glass, over a period of time it will be evenly distributed by mixing. Thus it tends to reach a state of thermodynamic equilibrium. This process cannot be reversed in real life due to the laws of physics. However, consider a model designed which is able to reverse the mixing of the paint in the glass in such a way that it is able to miraculously able to turn back time to the point where the paint just made contact with the glass. In layman’s terms this is how the diffusion model works.

The Diffusion model undergoes training by **destroying training data** through data preprocessing followed by a **Forward Diffusion** process. In this process the model destroys training data through successive addition of **Gaussian noise**. The noise added at each step varies depending on the schedule it follows like the **linear and cosine schedules**. Forward diffusion is done in a series of **reversible, incremental modifications, where each step can only be traced back to its previous step**. These steps are a part of the **Markov chain**. Once the image is converted to pure noise state, **Reverse Diffusion** process begins. In this process the model returns the image back to its original state by tracing the path back the Markov chain. **Once the model has been trained sufficiently, it is able to produce high quality data by passing randomly sampled noise through the learned denoising process**.

**The essential idea is to systematically and slowly destroy structure in a data distribution through an iterative forward diffusion process. We then learn a reverse diffusion process that restores structure in data, yielding a highly flexible and tractable generative model of the data.**

Benefits

Diffusion models are being widely using in digital art creation. It enables creators and artists to explore new styles and ideas. Diffusion models can be used to create images, graphic designs, films as well as animations.

The de-noising algorithms used in models are utilized in Large Language Models (LLMs) to understand and interpret complex user text input and produce appropriate responses.

It provides strategic insights into product adoption rates and spread of innovation. It is extremely useful in the business world.

They also help in decoding complex human behaviour which helps marketers and psychologists understand human thinking pattern and decision making.