DL lab 7 -Autoencoders

1. When above AE is used without activation functions, it is called a linear AE. Explain the relationship between linear AE and principal component analysis (PCA). Write the answer in a word file.

* When a linear autoencoder (AE) is used without activation functions, it behaves similarly to Principal Component Analysis (PCA).
* Linear Transformation: Both linear AEs and PCA are methods that transform data using linear equations. PCA finds directions (called principal components) where the data varies the most, while a linear AE compresses and then reconstructs the data using similar linear transformations.
* Dimensionality Reduction: PCA reduces the data to a smaller set of important components (principal components) to simplify it. A linear AE does something similar by compressing the data in its middle layer (encoder) and trying to reconstruct it later (decoder). Without activation functions, this process becomes very similar to PCA.
* Reconstruction Error: Both methods try to reduce the difference between the original data and the reconstructed data (after reducing dimensions). PCA does this by focusing on the most important directions of the data, and a linear AE aims to do the same without using any nonlinear operations.

4. Observe the model performance improvements between the above two models and give reasons for the observed improvements.

* Spatial Features: CNNs are better at capturing local patterns and spatial relationships (like edges or textures in images), while FFNNs treat all data equally without considering spatial structure.
* Efficiency: CNNs use fewer parameters because of shared filters, making them more efficient and less prone to overfitting compared to FFNNs, which require many more parameters.
* Complex Data: CNNs are designed for complex data like images, which have 2D structures. They learn progressively more complex features, leading to better performance.

1. Observe the model performance improvements between the Image De-noising AE and the Vanilla CNN AE.
   1. Explain the reasons for the observed improvements.

* Task Specialization: The Image De-noising AE is specifically designed for removing noise from images, making it more specialized for tasks involving noisy data. It learns to map noisy images to clean versions effectively.
* Noise Reduction: The de-noising AE is trained to focus on essential features by removing noise, which improves reconstruction quality. The Vanilla CNN AE might focus more on general feature extraction rather than noise reduction.
* Training Objective: In de-noising AE, the model is trained to minimize the difference between noisy inputs and clean outputs, leading to better results for de-noising tasks compared to the Vanilla CNN AE, which doesn’t focus on noise removal.

1. Explain the differences between AE and Variational AE (VAE).

* Autoencoder (AE):
* AE maps input data to a compressed representation (latent space) and reconstructs it. It focuses on reducing reconstruction error.
* The latent space in a standard AE doesn’t have a well-defined structure, making it less useful for generating new data.
* Variational Autoencoder (VAE):
* VAE introduces a probabilistic approach by assuming the latent space follows a known distribution (usually Gaussian).
* Instead of learning a single point in the latent space, VAE learns a distribution, allowing it to generate new, diverse data samples.
* VAEs are better at generating new data points that resemble the training data because of the structured latent space.