# Deep Learning Questions

## Deep Learning for Computer Vision

1. 1. \*\*What is an activation function and why is it important?\*\*

- An activation function introduces non-linearity into the neural network model, allowing it to learn complex patterns. Without non-linearity, the entire network would behave like a linear model, limiting its capacity.

1. 2. \*\*Explain the role of the softmax activation function in multi-class classification problems.\*\*

- Softmax converts the raw output scores (logits) from the network into probability distributions over multiple classes, ensuring that the sum of the probabilities equals one. It is ideal for multi-class classification.

3. \*\*CNN: What are we learning in practice?\*\*

- CNNs learn hierarchical spatial features from the data. Lower layers often detect edges or textures, while deeper layers may detect more complex patterns or even objects.

4. \*\*CNN: What is the role of pooling?\*\*

- Pooling (e.g., max-pooling) reduces spatial dimensions, thereby reducing the computational load and number of parameters. It also provides a form of spatial invariance.

5. \*\*What are the three main dataset splits used while training neural networks?\*\*

- Training, Validation, and Test. Splitting helps in: training the model, tuning hyperparameters, and assessing its generalization. Evaluation is usually done on the Test set.

6. \*\*What is the link between deep learning and automatic selection of features? Why is it useful?\*\*

- Deep learning models, especially CNNs, learn feature representations directly from raw data without manual feature extraction. This automatic feature learning is powerful, removing the need for domain-specific expertise in many cases.

7. \*\*What is the purpose of upsampling layers in segmentation networks?\*\*

- Upsampling layers increase spatial resolution, enabling the model to make detailed pixel-wise predictions, crucial for segmentation tasks.

8. \*\*Difference between semantic segmentation and instance segmentation?\*\*

- Semantic segmentation assigns a class to each pixel but doesn't differentiate between separate objects of the same class. Instance segmentation not only assigns classes but also distinguishes individual object instances.

9. \*\*Role of the learning rate in optimization algorithms?\*\*

- The learning rate determines the step size during optimization. It affects the convergence speed and stability of the learning process.

10. \*\*What happens when the learning rate is high? What when it is low?\*\*

- High: May cause divergence or oscillations in loss.

Low: Training becomes slower and might get stuck in local minima.

11. \*\*Why is mini-batch gradient descent preferred?\*\*

- It combines the best of both methods: the computational efficiency of SGD and the stability and faster convergence of batch gradient descent.

12. \*\*Meaning when validation loss increases and training loss decreases?\*\*

- This often indicates overfitting: the model is becoming too specialized to the training data and performing poorly on unseen data.

13. \*\*How can we find out when to stop training?\*\*

- Early stopping: Monitor validation loss, and stop training when it starts increasing or doesn't improve for a set number of epochs.

14. \*\*How to tell if the model is underfitting? How to avoid it?\*\*

- If both training and validation losses are high, or the model performs poorly on both. Avoid by: increasing model complexity, training longer, or using more features.

15. \*\*What is transfer learning? Benefits?\*\*

- Transfer learning involves using a pre-trained model on a new, related task. Benefits: faster convergence, less data required, and often better performance due to knowledge transfer.

16. \*\*Why do we need data augmentation?\*\*

- Augmentation artificially expands the training dataset with slight modifications, increasing model robustness and preventing overfitting.

17. \*\*Why do we need regularization methods?\*\*

- To prevent overfitting by adding penalties on model complexity, ensuring the model generalizes well on unseen data.

## Generative Models

1. What are the two main applications of generative models?

Image generation and data augmentation.

Classification

1. What is the difference between generative and discriminative models?

Generative models capture the data distribution to generate new samples, while discriminative models learn boundaries between classes to classify data.

1. What is a latent space? Why do we learn reduced dimensional representations?

Latent space: A compressed representation of data. Reduced dimensional representations allow efficient data processing, visualization, and capture essential features.

*Latent Space:*

*A latent space refers to a compressed or reduced-dimensional representation of data in a space where similar data points are closer together. It captures the essential characteristics or structures in the data, often learned by algorithms like autoencoders or other dimensionality reduction methods.*

Reasons for learning reduced dimensional representations:

**Data Compression:** Reducing dimensions can significantly decrease storage requirements and computational costs.

**Noise Reduction:** By focusing on primary features or structures in the data, one can often ignore or reduce noise or irrelevant variations.

**Visualization**: High-dimensional data can be challenging to visualize. Reducing dimensions (e.g., to 2D or 3D) allows for visualization techniques that can help in understanding patterns, clusters, or relationships in the data.

**Overfitting Mitigation**: In machine learning, models with fewer parameters or inputs are less likely to overfit to the training data. Reducing dimensions can be a way to prevent overfitting.

Improved Performance: In some cases, algorithms can perform better when they operate in a reduced-dimensional space, especially if the reduction captures the most informative features of the data.

Facilitating Data Processing: Many algorithms can run faster with fewer dimensions, leading to quicker results or allowing for processing larger datasets.

Semantic Understanding: In some contexts, like deep learning, the latent space might capture semantically meaningful aspects of the data, which can be useful for tasks like interpolation, clustering, or even generating new data samples.

In essence, reduced dimensional representations allow for efficient and often more effective data processing, understanding, and modeling.

1. What does an encoder do?

Encoder's function: Transforms input data into a reduced-dimensional latent representation.

1. What is the role of a decoder?

Reconstructs data from its latent representation.

1. In autoencoders and VAEs, why are the reconstructed images blurry?

Due to the model's averaging effect when learning general representations.

Because of the loss of information.

1. How do autoencoders help in image denoising?

They can learn to reconstruct noise-free images from noisy inputs.

1. What are the drawbacks of autoencoders? How does VAE address them?

Can overfit and might not ensure a smooth latent space. **VAEs** introduce a probabilistic approach to enforce continuity and regularize the latent space.

1. What is the KL loss term in VAEs? What does it do?

Kullback-Leibler divergence measures the difference between learned latent distribution and a prior (usually Gaussian). It ensures the latent space has good properties.

1. What is the reparameterization trick in VAEs?

A method to backpropagate through random nodes by separating randomness and ensuring gradients flow.

1. Explain the working principle of GANs.

A generator creates fake data, and a discriminator distinguishes between real and fake. They're trained adversarially to improve each other.

1. What is mode collapse?

When a GAN's generator produces limited variety, often outputting similar or identical samples.

1. What are conditional GANs? How are they different from the normal GANs?

**Conditional GANs:** GANs conditioned on additional information, like a label, making generation controlled. **Difference from normal GANs:** They use external information for generation.

1. Explain the working principle of diffusion models.

They transform data into a noise process and reverse this process. It learns to denoise iteratively, simulating the data generation as a diffusion process.