**Data Science Fundamentals (Approx. 25 Questions)**

1. **What is the difference between supervised and unsupervised learning?**
   * Supervised learning uses labeled data for training, while unsupervised learning uses unlabeled data to find patterns.
2. **Explain the bias-variance tradeoff.**
   * Bias is the error from incorrect assumptions, while variance is the error from sensitivity to fluctuations in the training data. The tradeoff involves finding a balance to minimize total error.
3. **What are the common steps in a data science project?**
   * Data collection, cleaning, exploration, modeling, evaluation, and deployment.
4. **How do you handle missing data?**
   * Imputation (mean, median, mode), deletion, or using algorithms that can handle missing values.
5. **What are outliers and how do you detect them?**
   * Outliers are data points significantly different from others. Detection methods include visualization (box plots, scatter plots), statistical methods (z-score, IQR), and machine learning techniques.
6. **Explain the difference between correlation and causation.**
   * Correlation indicates a relationship between variables, while causation implies that one variable directly influences another. Correlation doesn't imply causation.
7. **What is p-value?**
   * The probability of observing data as extreme as, or more extreme than, the data obtained, assuming the null hypothesis is true.
8. **What is the Central Limit Theorem?**
   * The distribution of sample means approximates a normal distribution as the sample size gets larger, regardless of the population's distribution.
9. **How do you perform feature scaling, and why is it important?**
   * Normalization (scaling to a range like 0-1) or standardization (scaling to have zero mean and unit variance). Important for algorithms sensitive to feature scales.
10. **What is cross-validation and why is it used?**
    * A technique to evaluate model performance on unseen data by splitting the data into multiple folds for training and testing. It provides a more robust estimate of generalization.
11. **Explain the difference between precision and recall.**
    * Precision is the proportion of correctly predicted positives out of all predicted positives. Recall is the proportion of correctly predicted positives out of all actual positives.
12. **What is the F1-score?**
    * The harmonic mean of precision and recall, providing a balanced measure of a model's accuracy.
13. **What is AUC-ROC curve?**
    * Area Under the Receiver Operating Characteristic curve. It plots the true positive rate against the false positive rate at various threshold settings and measures the model's ability to distinguish between classes.
14. **How do you handle imbalanced datasets?**
    * Oversampling the minority class, undersampling the majority class, using synthetic data generation techniques (e.g., SMOTE), or using cost-sensitive learning.
15. **What are different types of data visualization techniques?**
    * Bar charts, line charts, scatter plots, histograms, box plots, heatmaps, etc., each suitable for different data types and insights.
16. **What is the curse of dimensionality?**
    * As the number of features (dimensions) increases, data becomes sparse, and the performance of some algorithms degrades.
17. **How do you perform dimensionality reduction?**
    * Techniques like Principal Component Analysis (PCA), t-SNE, and feature selection methods.
18. **What is the difference between a long format and a wide format in data?**
    * Long format has each observation on a separate row with a variable indicating the measurement type. Wide format has each variable in a separate column.
19. **What are the key principles of data governance?**
    * Data quality, data security, data privacy, data integrity, and compliance.
20. **How do you measure the similarity between two data points?**
    * Distance metrics like Euclidean distance, Manhattan distance, cosine similarity, etc.
21. **What is A/B testing?**
    * A method of comparing two versions of something (e.g., a webpage, an algorithm) to determine which performs better.
22. **Explain the concept of statistical power.**
    * The probability of correctly rejecting a false null hypothesis.
23. **What are confidence intervals?**
    * A range of values that is likely to contain the true value of a population parameter with a certain degree of confidence.
24. **How do you evaluate the performance of a regression model?**
    * Metrics like Mean Squared Error (MSE), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and R-squared.
25. **What are the assumptions of linear regression?**
    * Linearity, independence of errors, homoscedasticity (constant variance of errors), and normality of errors.

**Machine Learning (Approx. 30 Questions)**

1. **Explain the working principle of linear regression.**
   * Finding the best-fitting line (or hyperplane in higher dimensions) that minimizes the sum of squared differences between predicted and actual values.
2. **Explain the working principle of logistic regression.**
   * Uses a sigmoid function to model the probability of a binary outcome.
3. **What are the different types of regularization techniques in linear models, and why are they used?**
   * L1 (Lasso) and L2 (Ridge) regularization. Used to prevent overfitting by adding a penalty term to the cost function, shrinking the coefficients.
4. **Explain the working principle of a decision tree.**
   * A tree-like structure where each internal node represents a feature, each branch represents a decision rule, and each leaf node represents an outcome.
5. **How does a random forest algorithm work?**
   * An ensemble method that builds multiple decision trees on random subsets of the data and features, and then averages their predictions.
6. **What is the concept of boosting in machine learning?**
   * An ensemble technique that sequentially builds models, where each new model tries to correct the errors made by the previous ones (e.g., AdaBoost, Gradient Boosting).
7. **Explain the working principle of Support Vector Machines (SVMs).**
   * Finds the optimal hyperplane that best separates different classes by maximizing the margin between them.
8. **What are kernels in SVMs?**
   * Functions that map data into a higher-dimensional space to allow for non-linear separation.
9. **Explain the working principle of K-Nearest Neighbors (KNN).**
   * Classifies a data point based on the majority class among its k nearest neighbors in the feature space.
10. **What is the elbow method used for in K-means clustering?**
    * To determine the optimal number of clusters (k) by plotting the within-cluster sum of squares against the number of clusters and looking for an "elbow" point where the rate of decrease slows down.
11. **Explain the difference between hierarchical clustering and K-means clustering.**
    * Hierarchical clustering builds a hierarchy of clusters (either top-down or bottom-up), while K-means partitions the data into a pre-defined number of non-overlapping clusters.
12. **What is Principal Component Analysis (PCA) and how does it work?**
    * A dimensionality reduction technique that finds the principal components (directions of maximum variance) in the data and projects the data onto a lower-dimensional subspace formed by these components.
13. **What is the difference between online and batch learning?**
    * Batch learning trains on the entire dataset at once, while online learning trains on data instances sequentially.
14. **What is transfer learning and when is it useful?**
    * Reusing knowledge gained from training one model on a large dataset for a different but related task with less data. Useful when you have limited data for the new task.
15. **What is the difference between generative and discriminative models?**
    * Discriminative models learn the decision boundary between classes (e.g., logistic regression, SVM), while generative models learn the joint probability distribution of the data and labels (e.g., Naive Bayes, Hidden Markov Models).
16. **Explain the concept of inductive bias in machine learning.**
    * The set of assumptions that a learning algorithm makes to prioritize one hypothesis over others.
17. **What are ensemble methods and why are they effective?**
    * Combining the predictions of multiple models to improve overall performance and robustness. Effective because different models may capture different aspects of the data or make different types of errors.
18. **What is the problem of overfitting and how can you prevent it?**
    * Overfitting occurs when a model learns the training data too well, including the noise, and performs poorly on unseen data. Prevention techniques include regularization, cross-validation, early stopping, and using more data.
19. **What is the problem of underfitting and how can you address it?**
    * Underfitting occurs when a model is too simple to capture the underlying patterns in the data and performs poorly on both training and unseen data. Addressing it involves using a more complex model, adding more features, or training for longer.
20. **What are hyperparameter tuning and some common techniques for it?**
    * Finding the optimal values for the parameters of a learning algorithm that are not learned from the data. Techniques include grid search, random search, and Bayesian optimization.
21. **What are the advantages and disadvantages of tree-based models?**
    * **Advantages:** Easy to interpret, can handle non-linear relationships, robust to feature scaling. **Disadvantages:** Prone to overfitting, can be unstable (high variance).
22. **What are the advantages and disadvantages of linear models?**
    * **Advantages:** Simple, computationally efficient, easy to interpret. **Disadvantages:** Can only model linear relationships, sensitive to outliers.
23. **Explain the concept of feature importance in tree-based models.**
    * A score indicating how useful each feature is for making predictions. It's often based on how much each feature reduces impurity (e.g., Gini impurity, entropy) in the tree.
24. **What is the difference between hard voting and soft voting in ensemble methods?**
    * Hard voting selects the class with the majority of votes from the individual classifiers. Soft voting averages the predicted probabilities from the individual classifiers and selects the class with the highest average probability.
25. **What is the concept of a learning rate in gradient descent?**
    * A hyperparameter that controls the step size at each iteration while moving towards a minimum of a loss function.
26. **What are different types of gradient descent?**
    * Batch gradient descent, stochastic gradient descent (SGD), and mini-batch gradient descent.
27. **What is momentum in the context of optimization algorithms?**
    * A technique that helps accelerate gradient descent by adding a fraction of the previous update vector to the current update vector, helping to overcome local minima and speed up convergence.
28. **What is early stopping?**
    * A regularization technique used during iterative training of a model where training is stopped when the performance on a validation set starts to degrade.
29. **Explain the concept of a confusion matrix.**
    * A table that summarizes the performance of a classification model by showing the counts of true positives, true negatives, false positives, and false negatives.
30. **What are the key assumptions of Naive Bayes?**
    * Conditional independence between features given the class label.

**Neural Networks (Approx. 30 Questions)**

1. **What is a neuron in a neural network and how does it work?**
   * The basic building block of a neural network, inspired by biological neurons. It receives inputs, performs a weighted sum, adds a bias, and applies an activation function to produce an output.
2. **What is an activation function and why is it important?**
   * A non-linear function applied to the output of a neuron. It introduces non-linearity into the network, allowing it to learn complex patterns. Common examples include ReLU, sigmoid, and tanh.
3. **Explain the architecture of a simple feedforward neural network.**
   * Consists of an input layer, one or more hidden layers, and an output layer. Information flows in one direction, from input to output.
4. **What is backpropagation and how does it work?**
   * The algorithm used to train artificial neural networks by calculating the gradient of the loss function with respect to the network's weights and biases, and then updating these parameters to minimize the loss.
5. **What is the role of the loss function in training a neural network?**
   * A function that quantifies the error between the network's predictions and the actual target values. The goal of training is to minimize this loss function.
6. **What is the difference between batch gradient descent, stochastic gradient descent (SGD), and mini-batch gradient descent?**
   * Batch GD uses the entire dataset to compute gradients, SGD uses a single data point, and mini-batch GD uses a small subset (batch) of the data.
7. **What is the vanishing gradient problem and how can it be mitigated?**
   * During backpropagation, gradients can become very small as they are propagated backward through many layers, making it difficult for earlier layers to learn. Mitigation techniques include using ReLU activation, batch normalization, and residual connections.
8. **What is the exploding gradient problem and how can it be mitigated?**
   * During backpropagation, gradients can become very large, leading to unstable training. Mitigation techniques include gradient clipping and using appropriate weight initialization.
9. **What is the purpose of weight initialization in neural networks?**
   * Setting the initial values of the network's weights to break symmetry and ensure that different neurons learn different features. Common methods include random initialization, Xavier/Glorot initialization, and He initialization.
10. **What is dropout and how does it help in regularization?**
    * A regularization technique where randomly selected neurons are ignored during training. This prevents co-adaptation of neurons and reduces overfitting.
11. **What is batch normalization and how does it help in training neural networks?**
    * A technique that normalizes the activations of intermediate layers within a mini-batch. It helps to stabilize training, allows for higher learning rates, and reduces the internal covariate shift.
12. **What are convolutional neural networks (CNNs) and what are they typically used for?**
    * A type of neural network that uses convolutional layers to automatically learn spatial hierarchies of features. Commonly used for image and video processing.
13. **Explain the function of convolutional layers, pooling layers, and fully connected layers in a CNN.**
    * **Convolutional layers:** Detect local patterns using filters. **Pooling layers:** Reduce the spatial dimensions of the feature maps. **Fully connected layers:** Perform the final classification or regression based on the learned features.
14. **What are recurrent neural networks (RNNs) and what are they typically used for?**
    * A type of neural network designed to process sequential data by maintaining a hidden state that captures information about past inputs. Commonly used for natural language processing, time series analysis.
15. **What are LSTMs and GRUs and why are they better than traditional RNNs for long sequences?**
    * Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU) are specialized RNN architectures that address the vanishing gradient problem by introducing memory cells and gating mechanisms to better capture long-range dependencies in sequential data.
16. **What are attention mechanisms in neural networks and how do they work?**
    * Mechanisms that allow the network to focus on the most relevant parts of the input sequence when processing it. They assign weights to different input elements based on their importance.
17. **What are transformers and what are their key advantages over RNNs for sequence modeling?**
    * A neural network architecture that relies entirely on attention mechanisms to model relationships between different positions in the input sequence. Advantages include parallel processing capabilities and better handling of long-range dependencies.
18. **Explain the concept of self-attention in transformers.**
    * An attention mechanism that allows the model to attend to different positions within the same input sequence to understand the relationships between them.
19. **What is the difference between encoder and decoder in a transformer architecture?**
    * The encoder processes the input sequence and creates a representation of it. The decoder uses this representation to generate the output sequence.
20. **What are embeddings in neural networks and why are they used?**
    * Dense vector representations of discrete entities (e.g., words, items). They capture semantic relationships and are used as input to neural networks.
21. **What is transfer learning in the context of deep learning?**
    * Reusing pre-trained models (trained on large datasets) as a starting point for a new task with less data. This can significantly speed up training and improve performance.
22. **What is fine-tuning a pre-trained model?**
    * Further training a pre-trained model on a new, smaller dataset specific to the target task. This often involves freezing some layers and training only the later layers.
23. **What are generative adversarial networks (GANs)?**
    * A type of generative model consisting of two neural networks: a generator that tries to create realistic data and a discriminator that tries to distinguish between real and generated data. They are trained in an adversarial manner.
24. **What are autoencoders?**
    * A type of neural network that learns to compress and then reconstruct the input data. The bottleneck layer in the middle learns a compressed representation (latent space).
25. **What are the different types of layers commonly used in neural networks?**
    * Dense (fully connected), convolutional, pooling, recurrent (LSTM, GRU), attention, normalization (batch norm, layer norm), embedding.
26. **How do you choose the appropriate activation function for different layers in a neural network?**
    * ReLU is common for hidden layers. Sigmoid or softmax is used for the output layer in binary or multi-class classification, respectively. Linear activation is used for regression output.
27. \*\*How do you determine the architecture (number of layers, number of neurons per layer) of a

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continue

Okay, let's continue with the interview questions.

**Neural Networks (Continued - Approx. 8 More Questions)**

1. **How do you determine the architecture (number of layers, number of neurons per layer) of a neural network?**
   * Often determined through experimentation and hyperparameter tuning. Considerations include the complexity of the problem, the amount of data, and computational resources. Techniques like grid search, random search, and Bayesian optimization can help.
2. **What are the common challenges in training deep neural networks?**
   * Vanishing/exploding gradients, overfitting, slow convergence, and the need for large amounts of labeled data.
3. **What are some techniques for visualizing the learned representations in neural networks?**
   * Dimensionality reduction techniques (like t-SNE or PCA) applied to the activations of hidden layers, visualizing filter weights in CNNs, and attention maps in transformers.
4. **What is the concept of transfer learning and why is it beneficial in deep learning?**
   * Reusing knowledge (weights and biases) learned from a pre-trained model on a large dataset for a new, often smaller, related task. Beneficial because it can lead to faster training, better generalization, and the ability to train effective models with less data.
5. **What are the ethical considerations related to using neural networks, especially in areas like facial recognition or natural language processing?**
   * Bias in training data leading to unfair or discriminatory outcomes, privacy concerns related to data collection and usage, and the potential for misuse of powerful AI technologies.
6. **What are graph neural networks (GNNs) and what type of data are they designed to process?**
   * Neural networks designed to operate on graph-structured data, where nodes have features and edges represent relationships between nodes. Used for tasks like node classification, link prediction, and graph classification.
7. **What are the differences between instance normalization, layer normalization, and batch normalization?**
   * **Batch Normalization:** Normalizes activations across the batch dimension. **Layer Normalization:** Normalizes activations across the feature dimension within each instance. **Instance Normalization:** Normalizes activations across the spatial dimensions (height and width) for each instance (often used in style transfer).
8. **What are the recent advancements in neural network architectures beyond transformers?**
   * Mixture of Experts (MoE) models, state-space models (like Mamba), and continued research into more efficient and interpretable architectures.

**Natural Language Processing (NLP) (Approx. 25 Questions)**

1. **What is tokenization in NLP?**
   * The process of breaking down a text into smaller units called tokens (e.g., words, subwords, characters).
2. **What is stemming and lemmatization? What's the difference?**
   * **Stemming:** Reducing words to their root form by removing suffixes (e.g., "running" -> "run"). **Lemmatization:** Reducing words to their dictionary base form (lemma) considering the word's meaning and context (e.g., "better" -> "good"). Lemmatization is generally more accurate.
3. **What are stop words and how are they handled in NLP?**
   * Common words (e.g., "the," "a," "is") that often don't carry significant meaning. They are often removed to focus on more important words.
4. **What is TF-IDF and how is it used in NLP?**
   * Term Frequency-Inverse Document Frequency. A numerical statistic that reflects how important a word is to a document in a collection of documents. Used for feature extraction in text analysis.
5. **What are word embeddings and why are they important?**
   * Dense vector representations of words that capture semantic relationships between them. Important because they allow NLP models to understand the meaning and context of words. Examples include Word2Vec, GloVe, and FastText.
6. **Explain the difference between bag-of-words and word embeddings.**
   * Bag-of-words represents text as a collection of words and their frequencies, ignoring word order and semantic relationships. Word embeddings represent words as dense vectors capturing semantic meaning.
7. **What are n-grams?**
   * Contiguous sequences of n items (e.g., words, characters) from a given text. Used to capture some local context.
8. **What are sequence-to-sequence models and what are they used for?**
   * Neural network architectures (often using RNNs or transformers) that map an input sequence to an output sequence. Used for tasks like machine translation, text summarization, and question answering.
9. **What is the role of the encoder and decoder in a sequence-to-sequence model?**
   * The encoder processes the input sequence into a fixed-length context vector, and the decoder uses this context vector to generate the output sequence.
10. **What is attention mechanism and how does it improve sequence-to-sequence models?**
    * Allows the decoder to focus on the most relevant parts of the input sequence at each step of the output generation, improving performance, especially for long sequences.
11. **What are transformers and why have they become dominant in NLP?**

* Neural network architecture based entirely on attention mechanisms. Dominant due to their ability to process sequences in parallel, handle long-range dependencies effectively, and achieve state-of-the-art results on various NLP tasks.

1. **What are the key components of the transformer architecture?**

* Self-attention mechanisms, multi-head attention, positional encoding, encoder and decoder stacks, feedforward networks, and normalization layers.

1. **What are large language models (LLMs)?**

* Deep learning models with a very large number of parameters, trained on massive amounts of text data, capable of generating coherent and contextually relevant text. Examples include GPT, BERT, and T5.

1. **What is pre-training and fine-tuning of LLMs?**

* **Pre-training:** Training an LLM on a massive general-purpose text corpus to learn general language representations. **Fine-tuning:** Adapting a pre-trained LLM to a specific downstream task using a smaller, task-specific dataset.

1. **What are different types of language modeling tasks?**

* Causal language modeling (predicting the next word), masked language modeling (predicting masked words), and sequence-to-sequence language modeling.

1. **What is zero-shot, one-shot, and few-shot learning in the context of LLMs?**

* **Zero-shot:** Performing a task without any task-specific examples. **One-shot:** Performing a task with only one example. **Few-shot:** Performing a task with a small number of examples.

1. **What are the challenges and limitations of current LLMs?**

* Potential for bias, generating factually incorrect information (hallucinations), difficulty with reasoning and common sense, high computational cost, and ethical concerns.

1. **What are some common NLP tasks?**

* Text classification, sentiment analysis, named entity recognition, machine translation, text summarization, question answering, topic modeling.

1. **What are the common evaluation metrics for different NLP tasks (e.g., text classification, machine translation)?**

* **Text Classification:** Accuracy, precision, recall, F1-score. **Machine Translation:** BLEU, METEOR.

1. **What is named entity recognition (NER)?**

* The task of identifying and classifying named entities (e.g., person names, organizations, locations) in text.

1. **What is sentiment analysis?**

* The task of determining the emotional tone or attitude expressed in a piece of text (e.g., positive, negative, neutral).

1. **What is topic modeling?**

* An unsupervised learning technique used to discover the underlying topics in a collection of documents. Examples include LDA and NMF.

1. **What are the ethical considerations in developing and deploying NLP models?**

* Bias in language models leading to discriminatory outputs, privacy issues related to processing personal text data, and the potential for misuse in generating harmful content.

1. **How can you evaluate the fairness and bias of an NLP model?**

* By evaluating performance across different demographic groups, using specific bias detection datasets and metrics, and analyzing the model's outputs for stereotypical or harmful content.

1. **What are some techniques for mitigating bias in NLP models?**

* Data augmentation with more diverse data, bias-aware training objectives, and post-processing techniques to adjust model outputs.

**Generative AI (Approx. 20 Questions)**

1. **What is generative AI?**

* A type of artificial intelligence focused on creating new, realistic data samples that resemble the training data.

1. **What are some common types of generative AI models?**

* Generative Adversarial Networks (GANs), Variational Autoencoders (VAEs), Diffusion Models, Autoregressive Models (like those used in LLMs).

1. **Explain the working principle of Generative Adversarial Networks (GANs).**

* Two neural networks (generator and discriminator) are trained in an adversarial manner. The generator tries to create realistic data, while the discriminator tries to distinguish between real and generated data.

1. **What are the applications of GANs?**

* Image generation, image editing, text-to-image synthesis, video generation, data augmentation, and drug discovery.

1. **Explain the working principle of Variational Autoencoders (VAEs).**

* Probabilistic generative models that learn a latent representation of the input data and then sample from this latent space to generate new data. They consist of an encoder that maps input to a probability distribution in the latent space and a decoder that maps samples from this distribution back to the data space.

1. **What are the applications of VAEs?**

* Anomaly detection, data compression, and generating new data with controlled variations.

1. **Explain the working principle of Diffusion Models.**

* Generative models that learn to reverse a gradual noising process. They start with random noise and iteratively denoise it to generate realistic data samples.

1. **What are the applications of Diffusion Models?**

* High-quality image generation, text-to-image synthesis, and video generation, often achieving state-of-the-art results.

1. **How do autoregressive models work for generation (e.g., in language or image generation)?**

* They generate data sequentially, predicting the next element based on the previously generated elements. For example, in language models, they predict the next word given the preceding words.

1. **What are the challenges in evaluating generative AI models?**

* Subjectivity of generated content, difficulty in defining appropriate evaluation metrics, and the need to assess both the quality and diversity of the generated samples.

1. **What are some common evaluation metrics for generative AI models (e.g., for images)?**

* Inception Score (IS), Fréchet Inception Distance (FID), Precision and Recall.

1. **What are the ethical considerations associated with generative AI?**

* Generation of fake content (deepfakes), copyright issues related to training data, potential for misuse in creating harmful or misleading information, and the impact on creative industries.

1. **What is text-to-image generation and what are some popular models for it?**

* The task of generating images from textual descriptions. Popular models include DALL-E, Stable Diffusion, and Midjourney.

1. **What is image-to-image translation and what are some common techniques?**

* The task of transforming an input image into a corresponding output image based on a given prompt or style. Techniques include using GANs (e.g., CycleGAN, Pix2Pix).

1. **What is the concept of latent space in generative models?**

* A lower-dimensional representation of the input data learned by the model, where semantically similar data points are close to each other. Manipulating points in the latent space can generate variations of the original data.

1. **How can we control the generation process in generative AI models?**

* Using conditional generation techniques (e.g., providing class labels or text prompts), manipulating the latent space, and using guidance techniques (e.g., classifier-free guidance in diffusion models).

1. **What are some recent advancements in generative AI beyond image and text?**

* Generation of audio, video, 3D models, and even molecules for drug discovery.

1. **What are the computational resources typically required to train and run generative AI models?**

* Often require significant computational resources, including powerful GPUs and large amounts of memory, especially for large-scale models.

1. **What are some techniques for making generative AI models more efficient?**

* Model compression techniques (e.g., pruning, quantization), knowledge distillation, and efficient model architectures.

1. **How can generative AI be used for data augmentation?**

* By generating synthetic data samples that resemble the real data, which can help improve the performance and robustness of other machine learning models, especially when real data is limited.

**Agentic AI (Approx. 15 Questions)**

1. **What is Agentic AI?**

* AI systems designed to perceive their environment, make decisions, and take actions autonomously to achieve specific goals.

1. **What are the key components of an AI agent?**

* Perception (sensing the environment), cognition (reasoning and decision-making), and action (interacting with the environment).

1. **What are the different types of AI agents (e.g., simple reflex agents, model-based reflex agents, goal-based agents, utility-based agents)?**

* **Simple Reflex Agents:** React directly to percepts. **Model-Based Reflex Agents:** Maintain an internal state based on history. **Goal-Based Agents:** Act to achieve specific goals. **Utility-Based Agents:** Act to maximize a utility function.

1. **What is reinforcement learning and how is it related to Agentic AI?**

* A type of machine learning where an agent learns to behave in an environment by receiving rewards or penalties for its actions. It's a key technique for enabling autonomous decision-making in Agentic AI.

1. **Explain the concepts of environment, state, action, reward, and policy in reinforcement learning.**

* **Environment:** The world the agent interacts with. **State:** The current situation of the agent. **Action:** What the agent can do. **Reward:** Feedback from the environment. **Policy:** A mapping from states to actions.

1. **What are some challenges in building effective AI agents?**

* Defining clear goals and reward functions, dealing with complex and dynamic environments, ensuring safety and ethical behavior, and handling uncertainty.

1. **What are some applications of Agentic AI?**

* Robotics, autonomous vehicles, game playing, personal assistants, recommendation systems, and automated trading.

1. **What is the concept of memory and planning in AI agents?**

* **Memory:** The ability to store and recall past experiences to inform current decisions. **Planning:** The ability to reason about future actions and their consequences to achieve goals.

1. **How do large language models contribute to the development of more sophisticated AI agents?**

* LLMs can provide agents with natural language understanding, generation, and reasoning capabilities, enabling more complex interactions and decision-making.

1. **What is the role of tools and APIs in enhancing the capabilities of AI agents?**

* Tools and APIs allow agents to interact with external systems and access information, extending their functionality and enabling them to perform a wider range of tasks.

1. **What are some examples of AI agent frameworks or platforms?**

* LangChain, AutoGPT, and various robotics frameworks.

1. **What are the safety considerations for deploying autonomous AI agents?**

* Ensuring agents operate within ethical boundaries, preventing unintended consequences, and handling potential failures or unforeseen situations.

1. **How can we evaluate the performance of an AI agent?**

* Based on its ability to achieve its goals, its efficiency, its robustness to changes in the environment, and its safety.

1. **What is the difference between a reactive agent and a deliberative agent?**

* **Reactive Agents:** Respond immediately to the current environment without significant internal reasoning. **Deliberative Agents:** Reason about goals, plan actions, and consider future consequences.

1. **What is the concept of agency in the context of AI?**

* The capacity of an AI system to act independently and make its own decisions to pursue its objectives.

1. **What are the future trends and potential impact of Agentic AI?**

* Increased automation across various industries, the development of more personalized and intelligent systems, and potentially transformative impacts on society.

I hope these questions and answers are helpful for your interview preparation! Good luck! Let me know if you have any other questions.

**Data Science Fundamentals (10 Additional Questions)**

1. **Explain the difference between Type I and Type II errors in hypothesis testing.**
   * **Type I Error (False Positive):** Rejecting a true null hypothesis. Probability denoted by α.
   * **Type II Error (False Negative):** Failing to reject a false null hypothesis. Probability denoted by β. Power of the test is 1−β.
2. **How would you design an experiment to test the effectiveness of a new website feature?**
   * Define clear objectives and KPIs (e.g., conversion rate, time on page).
   * Identify target audience and create control and treatment groups (A/B testing).
   * Randomly assign users to groups.
   * Run the experiment for a sufficient duration and sample size.
   * Collect and analyze data using appropriate statistical methods to determine if the difference in KPIs between groups is statistically significant.
   * Document findings and make recommendations.
3. **What are the key considerations when cleaning and preparing time series data?**
   * Handling missing values (imputation or removal).
   * Detecting and treating outliers.
   * Ensuring data is in the correct temporal order.
   * Handling seasonality and trends (decomposition, differencing).
   * Checking for stationarity (using statistical tests like ADF).
   * Resampling data to appropriate frequencies.
4. **Describe different techniques for handling categorical features in a dataset.**
   * **Nominal:** One-hot encoding, dummy coding.
   * **Ordinal:** Label encoding, ordinal encoding (mapping to numerical values based on order).
   * **High Cardinality:** Grouping less frequent categories, using target encoding, or embedding techniques.
5. **How do you assess the statistical significance of your findings in a data analysis project?**
   * Performing hypothesis tests and examining the p-value. A small p-value (typically < 0.05) indicates strong evidence against the null hypothesis.
   * Calculating confidence intervals to estimate the range of plausible values for a population parameter.
   * Considering the effect size and practical significance in addition to statistical significance.
6. **What are the potential pitfalls of using aggregated data?**
   * Loss of granularity and detail.
   * Ecological fallacy (making inferences about individuals based on group-level data).
   * Simpson's paradox (trends appearing in different groups disappear or reverse when the groups are combined).
   * Masking of important variations within groups.
7. **Explain the concept of cohort analysis and when it is useful.**
   * Cohort analysis groups users or data points based on a shared characteristic or time period (e.g., signup month, first purchase date) and then tracks their behavior over time.
   * Useful for understanding user retention, identifying trends in behavior across different groups, and evaluating the impact of changes or interventions on specific cohorts.
8. **How do you approach exploratory data analysis (EDA) for a new and unfamiliar dataset?**
   * Start by understanding the data's structure (number of rows and columns, data types).
   * Calculate descriptive statistics (mean, median, standard deviation, etc.).
   * Visualize data distributions (histograms, box plots).
   * Explore relationships between variables (scatter plots, correlation matrices).
   * Identify missing values and outliers.
   * Look for patterns, anomalies, and potential insights.
   * Formulate initial hypotheses and questions for further investigation.
9. **What are the different types of sampling techniques and when would you use each?**
   * **Simple Random Sampling:** Each member has an equal chance of being selected (unbiased).
   * **Stratified Sampling:** Divide population into subgroups (strata) and sample proportionally from each (ensures representation of subgroups).
   * **Cluster Sampling:** Divide population into clusters and randomly select entire clusters (efficient for large, geographically dispersed populations).
   * **Systematic Sampling:** Select every k-th member from an ordered list (easy to implement but can be biased if there's a pattern in the order).
   * **Convenience Sampling:** Select members who are easily accessible (quick but prone to bias).
10. **How do you communicate your data science findings to a non-technical audience?**
    * Focus on the business problem and the key insights.
    * Use clear and concise language, avoiding jargon.
    * Employ compelling visualizations (charts, graphs) that are easy to understand.
    * Tell a story with the data, highlighting the "so what?"
    * Provide actionable recommendations based on the findings.
    * Be prepared to answer questions in a simple and straightforward manner.

**Machine Learning (10 Additional Questions)**

1. **Explain the concept of stacking in ensemble learning.**
   * Combines predictions of multiple base models using another model (meta-learner).
   * Base models are trained on the data, and their outputs become features for the meta-learner.
   * The meta-learner learns the optimal way to weight or combine the base model predictions.
2. **How do you debug a machine learning model that is performing poorly?**
   * Check for data quality issues (missing values, outliers, inconsistencies).
   * Verify feature engineering steps.
   * Analyze training and validation performance (overfitting vs. underfitting).
   * Examine learning curves.
   * Try different algorithms or model architectures.
   * Tune hyperparameters.
   * Perform error analysis to understand common mistakes.
3. **What are some techniques for dealing with high cardinality categorical features?**
   * **Frequency Encoding:** Replace categories with their frequency in the dataset.
   * **Target Encoding:** Replace categories with the mean of the target variable for that category.
   * **Weight of Evidence (WOE) and Information Value (IV):** Used in credit scoring and binary classification.
   * **Dimensionality Reduction:** Techniques like principal component analysis (PCA) on encoded features.
   * **Embedding Techniques:** Learn low-dimensional representations for categories (similar to word embeddings).
4. **Explain the concept of active learning.**
   * A learning paradigm where the model strategically selects the most informative unlabeled data points for a human to label.
   * Aims to achieve high accuracy with fewer labeled examples by focusing on data where the model is most uncertain.
5. **How do you handle concept drift in a deployed machine learning model?**
   * Continuously monitor model performance on new data.
   * Detect drift using statistical methods or performance degradation.
   * Retrain the model periodically or trigger retraining when drift is detected.
   * Use online learning techniques to adapt to new data streams.
   * Implement A/B testing for new model versions.
6. **What are the trade-offs between different loss functions for classification and regression?**
   * **Classification:**
     + **Binary Cross-Entropy:** Sensitive to class imbalances.
     + **Categorical Cross-Entropy:** Suitable for multi-class, assumes mutually exclusive classes.
     + **Focal Loss:** Addresses class imbalance by down-weighting the contribution of well-classified examples.
   * **Regression:**
     + **Mean Squared Error (MSE):** Sensitive to outliers.
     + **Mean Absolute Error (MAE):** Robust to outliers.
     + **Huber Loss:** Hybrid of MSE and MAE, less sensitive to outliers than MSE.
7. **Explain the difference between a parameter and a hyperparameter in machine learning.**
   * **Parameter:** A value that is learned by the model during training (e.g., weights and biases in a neural network, coefficients in linear regression).
   * **Hyperparameter:** A value that is set before training and controls the learning process (e.g., learning rate, number of trees in a random forest, regularization strength).
8. **How do you ensure the reproducibility of your machine learning experiments?**
   * Set random seeds for all random number generators.
   * Version control your code and data.
   * Document all steps of the experiment (data preprocessing, model selection, hyperparameter tuning).
   * Use consistent library versions.
   * Save trained models and experiment configurations.
9. **What are some techniques for interpreting the predictions of complex machine learning models (model interpretability)?**
   * **LIME (Local Interpretable Model-agnostic Explanations):** Explains individual predictions by perturbing the input and observing changes in the output.
   * **SHAP (SHapley Additive exPlanations):** Uses game theory to assign importance values to each feature for a particular prediction.
   * **Feature Importance:** Provides a global view of which features are most important for the model's predictions (e.g., from tree-based models).
   * **Partial Dependence Plots (PDPs):** Show the marginal effect of one or two features on the predicted outcome.
10. **How do you select the appropriate machine learning algorithm for a given problem?**
    * Consider the type of problem (classification, regression, clustering).
    * Analyze the characteristics of the data (size, dimensionality, feature types).
    * Think about the interpretability requirements.
    * Evaluate the available computational resources and time constraints.
    * Start with simpler models and iterate to more complex ones if needed.
    * Experiment with multiple algorithms and compare their performance using appropriate evaluation metrics.

**Neural Networks (10 Additional Questions)**

1. **What are residual connections (skip connections) and why are they important in deep networks?**
   * Direct connections that bypass one or more layers, adding the input of a layer to the output of a later layer.
   * Help mitigate the vanishing gradient problem, allow the network to learn identity mappings, and facilitate training of very deep architectures.
2. **Explain the concept of transfer learning for different modalities (e.g., transferring knowledge from image to text).**
   * Leveraging knowledge learned from a model trained on one type of data (e.g., images) to improve performance on a task involving a different type of data (e.g., text).
   * Often involves using shared representations or learning mappings between the modalities. Examples include using image features to improve image captioning.
3. **What are the different types of recurrent layers beyond basic RNNs, LSTMs, and GRUs (e.g., bidirectional RNNs)?**
   * **Bidirectional RNNs (BRNNs):** Process the input sequence in both forward and backward directions, allowing the model to consider context from both past and future.
   * **Multi-layer RNNs:** Stack multiple recurrent layers to learn more complex temporal dependencies.
4. **How do you handle variable-length input sequences in neural networks?**
   * **Padding:** Add special tokens to shorter sequences to make them the same length as the longest sequence in a batch.
   * **Masking:** Use a mask to ignore the padded parts of the sequence during computation.
   * **Recurrent Neural Networks (RNNs):** Naturally handle variable-length sequences.
   * **Transformers:** Can handle variable lengths but often require padding and masking for batch processing.
5. **What are the challenges and techniques involved in training very deep neural networks?**
   * **Vanishing/Exploding Gradients:** Addressed by residual connections, batch normalization, proper weight initialization, and gradient clipping.
   * **Overfitting:** Mitigated by regularization techniques (dropout, weight decay), data augmentation, and early stopping.
   * **Computational Cost:** Reduced by techniques like gradient accumulation, mixed-precision training, and model parallelism.
6. **Explain the concept of attention mechanisms in the context of computer vision.**
   * Allow the model to focus on the most relevant parts of an image when processing it.
   * Can be spatial attention (focusing on specific regions), channel attention (focusing on important feature channels), or a combination of both. Used in tasks like image captioning, object detection, and image generation.
7. **What are graph neural networks (GNNs) used for, beyond the basic definition? Provide specific examples.**
   * Neural networks that operate on graph-structured data.
   * **Node Classification:** Predicting the category of a node (e.g., classifying users in a social network).
   * **Link Prediction:** Predicting whether an edge exists between two nodes (e.g., recommending connections in a social network).
   * **Graph Classification:** Predicting the category of an entire graph (e.g., classifying molecules).
   * **Applications:** Social network analysis, drug discovery, recommender systems, traffic prediction.
8. **How do you perform hyperparameter optimization for deep learning models?**
   * **Grid Search:** Exhaustively search over a predefined set of hyperparameter values.
   * **Random Search:** Sample hyperparameter values randomly from a defined range.
   * **Bayesian Optimization:** Uses probabilistic models to efficiently search the hyperparameter space.
   * **Automated Machine Learning (AutoML) tools:** Automate the process of model selection and hyperparameter tuning.
9. **What are the different ways to regularize a neural network to prevent overfitting?**
   * **L1 and L2 Regularization (Weight Decay):** Add a penalty term to the loss function based on the magnitude of the weights.
   * **Dropout:** Randomly sets a fraction of neuron activations to zero during training.
   * **Batch Normalization:** Normalizes the activations of intermediate layers, which can have a regularizing effect.
   * **Early Stopping:** Monitor performance on a validation set and stop training when it starts to degrade.
   * **Data Augmentation:** Increase the size and diversity of the training data by applying transformations.
10. **How do you deploy a trained neural network model for inference?**
    * **Model Serialization:** Save the trained model weights and architecture.
    * **Inference Engine:** Use optimized libraries (e.g., TensorFlow Lite, ONNX Runtime, TorchServe) for efficient computation.
    * **Deployment Platform:** Deploy on cloud servers, edge devices, or embedded systems.
    * **API Development:** Create an API endpoint to receive input data and return predictions.
    * **Monitoring:** Track model performance and resource usage in production.

**Natural Language Processing (10 Additional Questions)**

1. **Explain the concept of subword tokenization (e.g., Byte-Pair Encoding, WordPiece).**
   * Breaks down words into smaller, more frequent units (subwords).
   * Helps handle out-of-vocabulary (OOV) words and reduces vocabulary size.
   * **Byte-Pair Encoding (BPE):** Iteratively merges the most frequent pairs of characters or subwords.
   * **WordPiece:** Similar to BPE but selects merges based on likelihood maximization.
2. **What are the differences between various types of attention mechanisms (e.g., self-attention, cross-attention)?**
   * **Self-Attention:** Allows the model to attend to different positions within the *same* input sequence to understand relationships between words.
   * **Cross-Attention:** Allows the decoder to attend to the encoded input sequence when generating the output sequence (used in sequence-to-sequence models like transformers).
3. **How are language models evaluated for text generation quality beyond BLEU and METEOR?**
   * **Perplexity:** Measures how well the model predicts the next word in a sequence (lower is better).
   * **ROUGE (Recall-Oriented Understudy for Gisting Evaluation):** Used for summarization, measures overlap of n-grams between generated and reference summaries.
   * **Human Evaluation:** Assessing fluency, coherence, relevance, and factual correctness by human annotators.
   * **BERTScore:** Uses contextual embeddings from BERT to measure semantic similarity between generated and reference text.
4. **What are the challenges in handling multilingual text data?**
   * Different languages have different syntax, morphology, and vocabulary.
   * Data scarcity for some languages.
   * Need for models that can understand and process multiple languages effectively.
   * Challenges in alignment and translation.
5. **Explain the concept of knowledge graphs and their applications in NLP.**
   * Structured representations of knowledge consisting of entities (nodes) and relationships (edges).
   * **Applications:** Question answering (retrieving information), information extraction (identifying entities and relationships), semantic search (understanding the meaning of queries), and recommendation systems.
6. **How are NLP techniques used for information extraction?**
   * Identifying and extracting structured information from unstructured text.
   * Involves tasks like named entity recognition (NER), relation extraction (identifying relationships between entities), and event extraction (identifying events and their arguments).
7. **What are the recent advancements in handling long-context sequences in transformer models?**
   * **Sparse Attention:** Attending to only a subset of the input tokens to reduce computational cost.
   * **Memory-Augmented Transformers:** Incorporating external memory to store and retrieve information from long contexts.
   * **Recurrence in Transformers:** Introducing recurrent mechanisms to handle longer sequences more efficiently.
8. **How can NLP be used for tasks like code generation or understanding?**
   * **Code Generation:** Treating code as a sequence and using language models to predict the next token (code unit).
   * **Code Understanding:** Using NLP techniques to analyze code syntax and semantics to extract information, summarize code, or answer questions about code.
9. **What are the ethical considerations specific to large language models in areas like misinformation and bias amplification?**
   * Potential for generating realistic but false information (misinformation).
   * Risk of amplifying biases present in the training data, leading to unfair or discriminatory outputs.
   * Concerns about misuse for malicious purposes (e.g., generating harmful content).
10. **How do you adapt pre-trained language models for low-resource languages?**
    * **Cross-lingual transfer learning:** Leveraging knowledge from high-resource languages.
    * **Multilingual pre-training:** Training on data from multiple languages simultaneously.
    * **Back-translation:** Generating synthetic training data by translating text from the low-resource language to a high-resource language and back

continue

... (continued from the previous response about adapting pre-trained language models for low-resource languages)

* **Fine-tuning with limited data:** Carefully fine-tuning the pre-trained model on the small amount of available data for the low-resource language.
* **Using language-specific features:** Incorporating linguistic features specific to the low-resource language if available.

**Generative AI (10 Additional Questions)**

1. **What are normalizing flows and how do they work as generative models?**
   * Generative models that learn an invertible transformation between a simple probability distribution (e.g., Gaussian) and the complex data distribution.
   * By applying a sequence of invertible transformations, they can generate samples by transforming samples from the base distribution. The likelihood of the generated data can be explicitly calculated.
2. **Explain the concept of conditional generative models and provide examples.**
   * Generative models that can generate data with specific desired attributes by conditioning the generation process on additional input.
   * **Examples:**
     + **Conditional GANs (cGANs):** Generating images based on class labels or text descriptions.
     + **Conditional VAEs (cVAEs):** Generating data with specific attributes by conditioning the latent space.
     + Text-to-image models generating images from textual prompts.
3. **How can reinforcement learning be used to train generative models?**
   * By defining a reward function that measures the quality or desired characteristics of the generated samples.
   * The generative model (agent) learns to produce samples that maximize this reward, often through interaction with an environment or based on feedback. This is used in areas like text generation (e.g., improving coherence) and image generation (e.g., enhancing realism).
4. **What are the challenges in ensuring the diversity and novelty of generated samples?**
   * Generative models can sometimes collapse to generating only a few modes of the data distribution or produce samples that are very similar to the training data.
   * **Techniques to address this:** Encouraging exploration in the latent space, using loss functions that promote diversity, and employing mechanisms to detect and penalize mode collapse.
5. **How can we interpret the latent space learned by generative models?**
   * By analyzing how different dimensions in the latent space correspond to variations in the generated data.
   * Techniques include latent space traversals (interpolating between latent vectors and observing the changes in the generated output) and dimensionality reduction of the latent space for visualization.
6. **What are the techniques for evaluating the fidelity and realism of generated video?**
   * Beyond frame-level metrics used for images, video evaluation considers temporal coherence and motion realism.
   * **Metrics:** Fréchet Video Distance (FVD), temporal consistency metrics, and human evaluation studies.
7. **How can generative AI be used for drug discovery and materials science?**
   * **Drug Discovery:** Generating novel molecular structures with desired properties, predicting binding affinities, and designing drug candidates.
   * **Materials Science:** Designing new materials with specific characteristics by exploring the space of possible material compositions and structures.
8. **What are the security risks associated with generative AI models (e.g., adversarial attacks)?**
   * **Adversarial Attacks:** Crafting specific inputs that can cause generative models to produce unintended or harmful outputs (e.g., generating realistic fake images or text).
   * **Model Stealing:** Inferring the architecture or parameters of a proprietary generative model by observing its outputs.
9. **Explain the concept of style transfer in image generation.**
   * The technique of separating the content of one image from its style and applying the style to the content of another image using generative models.
10. **What are some of the latest advancements in 3D content generation using AI?**
    * Generating 3D shapes and scenes from text prompts or 2D images using models that can reason about 3D geometry.
    * Neural Radiance Fields (NeRFs) for creating photorealistic 3D representations from 2D images.
    * Generative models for creating textures, materials, and animations for 3D objects.

**Agentic AI (10 Additional Questions)**

1. **Explain the difference between model-free and model-based reinforcement learning in the context of agents.**
   * **Model-Free:** Agents learn directly from experience without explicitly learning a model of the environment's dynamics (e.g., Q-learning, SARSA).
   * **Model-Based:** Agents learn a model of the environment (transition probabilities and reward functions) and use it to plan and make decisions (e.g., value iteration, policy iteration with learned models).
2. **What are the challenges of multi-agent systems?**
   * **Coordination:** Getting multiple agents to work together effectively.
   * **Communication:** Enabling agents to share information.
   * **Non-stationarity:** The environment changes from the perspective of each agent as other agents learn and adapt.
   * **Credit Assignment:** Determining which agent is responsible for a particular outcome.
   * **Opponent Modeling:** Predicting the behavior of other agents.
3. **How can hierarchical reinforcement learning be used to build more complex agents?**
   * By breaking down complex tasks into a hierarchy of sub-tasks with their own goals and policies.
   * Higher-level controllers set abstract goals for lower-level controllers, which execute sequences of actions to achieve those sub-goals, allowing for more efficient exploration and learning in long-horizon tasks.
4. **What are the techniques for enabling exploration vs. exploitation in reinforcement learning agents?**
   * **ϵ-greedy:** Choosing the best-known action with probability 1−ϵ and a random action with probability ϵ.
   * **Boltzmann Exploration (Softmax):** Assigning probabilities to actions based on their estimated values (higher value = higher probability).
   * **Upper Confidence Bound (UCB):** Balancing exploitation with exploring uncertain actions.
5. **How can natural language be used as a form of communication with AI agents?**
   * Agents can understand instructions given in natural language using NLP techniques.
   * Agents can generate natural language to explain their actions, ask for clarification, or provide feedback.
   * This enables more intuitive and flexible interaction between humans and AI agents.
6. **What are the challenges in deploying AI agents in safety-critical environments?**
   * Ensuring reliability and robustness in unpredictable situations.
   * Handling edge cases and unforeseen events.
   * Verifying and validating the agent's behavior.
   * Addressing ethical concerns related to autonomous decision-making.
7. **Explain the concept of memory augmentation in AI agents.**
   * Equipping agents with mechanisms to store and retrieve past experiences or knowledge to inform current decision-making.
   * This can involve using external memory modules, attention over past states, or knowledge graphs.
8. **How can symbolic AI and neural networks be combined to create more robust agents?**
   * **Neuro-symbolic AI:** Integrating the strengths of both approaches.
   * Neural networks for perception and learning complex patterns.
   * Symbolic AI for reasoning, planning, and representing structured knowledge.
   * This can lead to agents that are more interpretable, robust, and capable of logical inference.
9. **What are the current limitations of autonomous AI agents?**
   * Lack of common sense reasoning.
   * Difficulty generalizing to novel situations significantly different from their training.
   * Challenges in understanding and interacting with the real world in a flexible and robust way.
   * Limitations in explainability and transparency of their decision-making processes.
10. **How can we ensure the transparency and explainability of decisions made by complex AI agents?**
    * Developing explainable AI (XAI) techniques tailored for agentic systems.
    * Providing justifications for actions, visualizing the agent's reasoning process, and allowing for human oversight and intervention.
    * Using more interpretable model architectures or extracting symbolic representations from learned models.