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Professional Certificate in AI for Digital Pathology

## Fundamentals of Artificial Intelligence

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**Artificial Intelligence (AI):** Artificial Intelligence refers to the simulation of human intelligence in machines that are programmed to think and act like humans. It involves the study and development of intelligent agents that can perceive their environment and take actions to achieve specific goals.

**Activation Function:** An activation function is a mathematical function that determines the output of a neural network. It introduces non-linearity to the network, allowing it to learn complex patterns in the data. Common activation functions include sigmoid, tanh, ReLU, and softmax.

**Backpropagation:** Backpropagation is a technique used to train neural networks by updating the weights of the network based on the error in the output. It calculates the gradient of the loss function with respect to the weights, allowing the network to learn from its mistakes.

**Classification:** Classification is a type of supervised learning where the goal is to predict the discrete class labels of input data. It involves training a model on labeled data to make predictions on new, unseen data.

**Clustering:** Clustering is an unsupervised learning technique where the goal is to group similar data points together based on their characteristics. It helps in identifying patterns and structures in the data without the need for labeled examples.

**Convolutional Neural Network (CNN):** A Convolutional Neural Network is a type of deep neural network commonly used for image recognition and computer vision tasks. It consists of convolutional layers that learn features from the input data and pooling layers that reduce the spatial dimensions of the features.

**Deep Learning:** Deep Learning is a subset of machine learning that involves training neural networks with multiple layers to learn complex patterns in the data. It has been successful in various domains such as computer vision, natural language processing, and speech recognition.

**Feature Engineering:** Feature Engineering is the process of selecting, transforming, and creating features from the raw data to improve the performance of machine learning models. It involves domain knowledge and creativity to extract meaningful information from the data.

**Gradient Descent:** Gradient Descent is an optimization algorithm used to minimize the loss function of a neural network by adjusting the weights iteratively in the direction of the steepest gradient. It is the foundation of training neural networks.

**Hyperparameter:** A hyperparameter is a parameter whose value is set before the learning process begins. It

controls the learning process of a machine learning algorithm and affects the performance of the model. Examples of hyperparameters include learning rate, number of hidden layers, and batch size.

**Image Segmentation:** Image Segmentation is the process of partitioning an image into multiple segments to simplify its representation and make it easier to analyze. It is commonly used in medical imaging for identifying different structures and abnormalities in images.

**Machine Learning:** Machine Learning is a subset of artificial intelligence that involves training algorithms to learn patterns from data and make predictions or decisions without being explicitly programmed. It enables computers to learn from experience and improve over time.

**Neural Network:** A Neural Network is a computational model inspired by the biological neural networks in the human brain. It consists of interconnected nodes (neurons) organized in layers that process input data and produce output. Neural networks are capable of learning complex patterns in the data.

**Overfitting:** Overfitting occurs when a machine learning model performs well on the training data but fails to generalize to new, unseen data. It happens when the model learns noise or irrelevant patterns in the training data, leading to poor performance on test data.

**Preprocessing:** Data Preprocessing is the initial step in the machine learning pipeline where raw data is transformed, cleaned, and prepared for training. It involves tasks such as data normalization, feature scaling, handling missing values, and encoding categorical variables.

**Reinforcement Learning:** Reinforcement Learning is a type of machine learning where an agent learns to make decisions by interacting with an environment. It receives feedback in the form of rewards or penalties based on its actions, allowing it to learn the optimal policy through trial and error.

**Regression:** Regression is a type of supervised learning where the goal is to predict continuous numerical values based on input data. It involves fitting a mathematical model to the data to estimate the relationships between variables.

**Supervised Learning:** Supervised Learning is a machine learning approach where the model is trained on labeled data, consisting of input-output pairs. The goal is to learn a mapping from input to output that can be generalized to make predictions on new, unseen data.

**Unsupervised Learning:** Unsupervised Learning is a machine learning approach where the model is trained on unlabeled data to discover patterns and structures in the data. The goal is to group similar data points together or reduce the dimensionality of the data without explicit labels.

**Validation Set:** A Validation Set is a portion of the dataset that is used to tune the hyperparameters of a machine learning model and evaluate its performance during training. It helps in preventing overfitting by providing an unbiased estimate of the model's generalization error.

**Artificial Neural Network (ANN):** An Artificial Neural Network is a computational model inspired by the biological neural networks in the human brain. It consists of interconnected nodes (neurons) organized in layers that process input data and produce output. Neural networks are capable of learning complex patterns in the data.

**Batch Normalization:** Batch Normalization is a technique used to improve the training of deep neural networks by normalizing the input to each layer. It helps in reducing internal covariate shift and allows the network to learn more efficiently.

**Computer Vision:** Computer Vision is a field of artificial intelligence that focuses on enabling computers to interpret and understand visual information from the real world. It involves tasks such as image recognition, object detection, and image segmentation.

**Data Augmentation:** Data Augmentation is a technique used to artificially increase the size of the training dataset by applying transformations such as rotation, translation, and flipping to the existing data. It helps in improving the generalization and robustness of machine learning models.

**Dropout:** Dropout is a regularization technique used in neural networks to prevent overfitting by randomly deactivating a fraction of neurons during training. It encourages the network to learn redundant representations and improves its generalization performance.

**Feature Extraction:** Feature Extraction is the process of reducing the dimensionality of the data by extracting relevant features that capture the essential information. It helps in improving the performance of machine learning models and reducing computational complexity.

**Generative Adversarial Network (GAN):** A Generative Adversarial Network is a type of neural network architecture that consists of two networks, a generator, and a discriminator, trained in a competitive manner. The generator generates fake data, while the discriminator distinguishes between real and fake data.

**Kernel:** A Kernel is a function used to compute the similarity between data points in a machine learning algorithm. It is commonly used in support vector machines and kernelized algorithms to map the input data into a higher-dimensional space for better separation of classes.

**Loss Function:** A Loss Function is a mathematical function that quantifies the difference between the predicted output of a machine learning model and the actual target values. It is used to measure the performance of the model during training and guide the optimization process.

**Object Detection:** Object Detection is a computer vision task that involves identifying and localizing objects within an image or video. It is commonly used in applications such as autonomous driving, surveillance systems, and facial recognition.

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**Optimization Algorithm:** An Optimization Algorithm is a method used to minimize the loss function and update the weights of a machine learning model during training. Common optimization algorithms include Gradient Descent, Adam, and RMSprop.

**Principal Component Analysis (PCA):** Principal Component Analysis is a dimensionality reduction technique used to transform high-dimensional data into a lower-dimensional space while preserving most of the variance in the data. It helps in visualizing and understanding the underlying structure of the data.

**Recurrent Neural Network (RNN):** A Recurrent Neural Network is a type of neural network architecture designed to handle sequential data by maintaining a state or memory of previous inputs. It is commonly used in natural language processing, time series analysis, and speech recognition.

**Semi-Supervised Learning:** Semi-Supervised Learning is a machine learning approach that combines labeled and unlabeled data to train a model. It leverages the labeled data to guide the learning process and uses the unlabeled data to improve the model's performance.

**Transfer Learning:** Transfer Learning is a machine learning technique where a pre-trained model is used as a starting point for training a new model on a different task or dataset. It helps in reducing the amount of labeled data required for training and speeding up the learning process.

**Underfitting:** Underfitting occurs when a machine learning model is too simple to capture the underlying patterns in the data, leading to poor performance on both the training and test data. It can be caused by using a model with insufficient complexity or inadequate training.

**Variational Autoencoder (VAE):** A Variational Autoencoder is a type of neural network architecture that combines an encoder and a decoder to learn a low-dimensional representation of the input data. It is used for generative modeling and unsupervised learning tasks such as image generation and data compression.

**Word Embedding:** Word Embedding is a technique used to represent words as dense vectors in a continuous vector space. It captures the semantic relationships between words and allows machine learning models to understand the meaning of words in a more meaningful way.

**Attention Mechanism:** An Attention Mechanism is a mechanism used in neural networks to focus on specific parts of the input data when making predictions. It helps in improving the performance of the model by assigning different weights to different parts of the input.

**Batch Size:** Batch Size is the number of data samples used in each iteration of training a machine learning model. It affects the speed and stability of training, with larger batch sizes leading to faster convergence but potentially slower generalization.

**Activation Function:** An Activation Function is a mathematical function that determines the output of a neural network. It introduces non-linearity to the network, allowing it to learn complex patterns in the data.

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