**2. Discuss your understanding of deep learning and how it differs from traditional machine learning methods.**

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**A. Early Machine Learning Approaches:**

Initially, traditional machine learning methods, such as decision trees, early artificial intelligence, and expert systems, relied on rule-based techniques to handle as many cases as possible. For instance, they might use a series of rules to distinguish between a cat and a dog. However, these methods often struggled to generalize across all practical scenarios.

**B. Traditional Machine Learning:**

Traditional machine learning approaches began to focus on extracting and transforming data features, often through manual feature engineering, and incorporating statistical methods to generate predictions.

These models typically have a small number of parameters, require only a modest amount of data for training, and can be trained on regular CPUs.

**Examples:**

* **Supervised:** Naïve Bayes, SVM, Shallow Neural Networks
* **Unsupervised:** PCA, K-means

Despite their usefulness, feature extraction and transformation in these models are limited and often require manual intervention. Over-reliance on statistical methods can introduce uncertainty.

Shallow neural networks, which is fully connected networks mimicking human neurons, are considered black-box models, making it difficult to explain their predictions.

They are often trained using stochastic gradient descent (SGD), which can lead to local optima and overfitting due to limited model capacity.

Shallow neural networks were primarily used in research rather than practical applications.

**C. Deep Learning:**

Deep learning has evolved from models like Restricted Boltzmann Machines (RBM), Autoencoders, RNNs, and CNNs to more advanced architectures. Modern deep learning models can automatically extract meaningful features and integrate feature computation with statistical methods more effectively.

The emergence of Convolutional Neural Networks (CNNs) and Transformer/Large Language Models (LLMs) has highlighted the potential of AI in perception and reasoning tasks, such as computer vision and natural language processing in both discriminative and generative approach. Moreover, combining computer vision and natural language processing has created powerful multimodal systems.

Long Short-Term Memory (LSTM) networks have also demonstrated the ability to handle long sequence data, such as time series and language.

* **CNN:** A CNN processes data by applying filters to extract features at different levels of abstraction.
* **Transformer:** A Transformer utilizes attention mechanisms to weigh the importance of different input parts for output prediction.
* **LSTM:** An LSTM is a recurrent neural network with memory cells capable of capturing long-term dependencies in sequential data.

Most deep learning models are supervised and require large datasets for training. However, architectures like few-shot and zero-shot learning have been introduced to address data limitations.

Besides SGD, optimizers like Adam and RMSProp have been developed to to train faster and more optimal the model with large numbers of parameters.

Deep learning models often require powerful computational resources, including multiple GPUs, for training.

Although these models are complex and still considered black boxes, efforts like GradCAM have been made to visualize and explain their predictions (Explainable AI).