

CSCI6379 Intro To Deep Learning

SPRING 2024

INSTRUCTOR: DR. DONG-CHUL KIM
dongchul.kim@utrgv.edu

Introduction

Artificial Intelligence, Machine Learning, Deep Learning

Artificial Intelligence

- Definition and Basic Concepts of Artificial Intelligence
 - Artificial Intelligence (AI) is the technology that enables computer systems to perform intelligent behaviors similar to humans. This includes learning, reasoning, problem-solving, perception, and language understanding. AI aims to mimic and sometimes surpass human intelligence, performing a variety of tasks. The main goal is to emulate or enhance human intellectual tasks through automated systems.
- Historical Development of AI Research: From Early Theories to Present
 - AI research began in the mid-20th century. The term "Artificial Intelligence" was first used at the Dartmouth Conference in 1956, which is considered the official launch of the AI field. Early research focused primarily on the symbolic approach, centering on reasoning and problem-solving based on logical rules.
 - In the 1980s, the development of expert systems and early forms of machine learning began. During this period, machine learning mainly used statistical methods and decision trees.
 - With the advent of the Internet in the 1990s, there was an explosive increase in data, fueling machine learning research. During this period, algorithms such as neural networks began to gain attention.

-
- In the 21st century, especially since the 2010s, the development of deep learning has innovatively advanced the field of AI. Deep learning has demonstrated performance surpassing humans in various fields, including image recognition, natural language processing, and gaming.
 - Major Milestones and Technical Developments in AI
 - 1997 IBM's Deep Blue: IBM's Deep Blue, which defeated world chess champion Garry Kasparov, was a significant event proving that AI can surpass human intelligence in specific intellectual tasks.
 - 2016 Google DeepMind's AlphaGo: AlphaGo's victory over world Go champion Lee Sedol demonstrated AI's capability to surpass humans in complex strategy games through the combination of deep learning and reinforcement learning.
 - Autonomous Vehicles and Voice Recognition Assistants: Autonomous driving technology and voice recognition assistants (Amazon's Alexa, Apple's Siri) are direct applications of AI in everyday life. They utilize complex environment perception, voice processing, and decision-making algorithms.
 - Personalized Recommendation Systems: Recommendation systems used by platforms like Netflix and YouTube offer personalized content through large-scale data analysis and learning.
 - ChatGPT: Developed by OpenAI, ChatGPT represents a major advancement in natural language processing. Based on the Generative Pre-trained Transformer (GPT), this chatbot can generate human-like conversations on a wide range of topics, demonstrating natural language understanding and generation capabilities. ChatGPT presents potential applications in customer service, education, entertainment, and more, showcasing the advancement of AI in language understanding and interaction.
 - These milestones illustrate how AI can mimic and sometimes surpass human intellectual tasks, providing an exciting outlook for the future of AI technology.
 -

Machine Learning

- Definition and Basic Concepts of Machine Learning
 - Machine Learning is a branch of Artificial Intelligence where computer systems learn from data, improving their performance through experience without

explicit programming. The goal is to enable computers to learn patterns from data and make predictions or decisions.

- Overview of the Learning Process and Algorithms
 - Machine learning algorithms analyze given data to build models for specific tasks (e.g., classification, prediction). The process involves feeding data into the model to make predictions, evaluating how much the model's predictions deviate from actual values, and continuously improving the model based on this feedback.
- Importance and Methodology of Feature Extraction and Feature Selection
 - Feature extraction and feature selection are crucial in machine learning for effectively processing data and optimizing model performance. Feature extraction is the process of deriving useful information from raw data, while feature selection involves choosing the most significant features to reduce model complexity and prevent overfitting.
- The Role and Importance of Data, and Data Preprocessing
 - In machine learning, data is the foundation of model training. High-quality data is a critical component in determining model performance. Data preprocessing involves making the data suitable for model training, including noise removal, handling missing values, and normalization.
- Introduction to the Concept of Models and Various Types
 - Machine learning models are implementations of algorithms that learn patterns from data to make predictions or classifications. Various types of models include linear regression, decision trees, random forests, support vector machines (SVM), and neural networks.
- Differences and Importance of Training, Validation, and Test Datasets
 - Training Dataset: Used to train the model.
 - Validation Dataset: Used to evaluate the model during training and adjust hyperparameters.
 - Test Dataset: Used to assess the final performance of the trained model. This dataset is not used during the model development process.
- Concepts and Differences between Supervised Learning, Unsupervised Learning, and Reinforcement Learning

-
- Supervised Learning: Involves training the model using labeled data. The model learns the relationship between input and the correct output.
 - Unsupervised Learning: Involves finding hidden patterns or structures in unlabeled data.
 - Reinforcement Learning: Involves an agent learning to maximize rewards through interactions with the environment. Reinforcement learning is mainly applied to problems related to decision-making processes.

Deep Learning

- Basic Structure and Principles of Neural Networks
 - Deep Learning is based on artificial neural networks composed of basic units called neurons. These neurons form layers, and the simplest neural network consists of an input layer, one or more hidden layers, and an output layer. Each neuron has weights and biases that are adjusted during the learning process.
- Key Differences Between Machine Learning and Deep Learning
 - While Deep Learning is a subset of Machine Learning, there are important differences:
 - Deep Learning is well-suited for large datasets, and its performance improves with more data.
 - Deep Learning automates the feature extraction process. Unlike traditional Machine Learning, which requires manual feature engineering, Deep Learning can learn features from the data.
- Deep Learning Algorithms
 - Deep Learning algorithms encompass various types of neural networks, each suitable for specific tasks. Key algorithms include:
 - Convolutional Neural Networks (CNNs): Primarily used for tasks like image recognition and classification, CNNs are designed to effectively extract important features from images.
 - Recurrent Neural Networks (RNNs): Used for tasks involving sequential data, such as natural language processing and time series analysis. RNNs can retain information from previous steps.

-
- Generative Adversarial Networks (GANs): Comprising a generator and a discriminator, GANs are used to generate realistic images, music, text, and more.
 - Deep Reinforcement Learning (Deep RL): Combines reinforcement learning with deep neural networks to address complex decision-making problems.
 - Recent Trends in Deep Learning Research and Technology
 - Large Language Models (LLMs): Models like GPT and BERT have achieved remarkable results in natural language processing tasks such as text generation, machine translation, and question-answering systems.
 - Generative AI Models: Models capable of generating images, music, text, and other content are advancing, enabling creative content generation, data augmentation, and even artistic endeavors.
 - Artificial General Intelligence (AGI): Current Deep Learning research is moving towards achieving AGI, which aims to develop systems with human-level intelligence capable of performing a wide range of intellectual tasks.

Deep Learning Training Process

- The training process of Deep Learning involves several steps to learn complex data patterns. These steps are as follows:
- Data Preparation:
 - High-quality and diverse datasets are crucial for Deep Learning model performance.
 - Prepare large-scale datasets and perform data preprocessing (e.g., normalization, noise removal, data augmentation) as needed.
- Model Design:
 - Design the model architecture, including the number of layers, neurons per layer, and connectivity.
 - The architecture can vary depending on the problem type (e.g., classification, regression) and data characteristics.
- Model Compilation:
 - Choose activation functions (e.g., ReLU, Sigmoid), loss functions (e.g., cross-entropy, mean squared error), and optimizers (e.g., Adam, SGD).
 - These choices significantly impact how the model learns and optimizes.

-
- Model Training:
 - Train the model on a large dataset.
 - Batch size selection affects memory usage and training speed.
 - Hyperparameter tuning (e.g., learning rate, number of epochs) is essential for model performance and overfitting prevention.
 - Model Evaluation:
 - Evaluate the model's performance on a separate test dataset.
 - Measure performance using various metrics such as accuracy, precision, recall, F1 score, etc.
 - Adjust and retrain the model if necessary to improve performance.
 - Through these steps, Deep Learning models learn from complex data, enabling them to make accurate predictions or classifications.