# Simplified AI Lecture 6 Summary: Deep Learning and Computer Vision

## Review of Basic Concepts

### What is AI?

* Artificial Intelligence is the ability of computers to perform tasks that normally require human intelligence
* AI systems can learn, reason, adapt, and solve problems

### What is Machine Learning?

* A subset of AI where computers learn from data without being explicitly programmed
* Different approaches: supervised learning, unsupervised learning, semi-supervised, reinforcement learning

## Deep Learning

### What is Deep Learning?

* Deep learning is a specialized branch of machine learning
* It uses neural networks with many layers (hence “deep”)
* These layers help the system learn different levels of features from data

### Deep Learning vs. Traditional Machine Learning

* Traditional machine learning often requires manual feature extraction (identifying important parts of the data)
* Deep learning can automatically discover the important features
* Deep learning models learn in a hierarchical way, similar to how our brains work
* Also called layered representation learning or hierarchical representation learning

### Key Concepts in Deep Learning

* The “depth” of a model refers to the number of layers it has
* Modern deep learning models can have dozens or even hundreds of layers
* Deep Learning = Machine Learning + Representation Learning
* Representation Learning allows machines to automatically discover important features from raw data

## Neural Networks

### What is a Neural Network?

* Computing systems inspired by the human brain
* Made up of connected units (neurons) organized in layers
* Neural networks are the foundation of deep learning
* They learn to recognize patterns in data and make predictions

### Types of Neural Networks

* **Artificial Neural Networks (ANNs)**: The general term for *brain*-inspired computing systems
* **Feedforward Neural Networks (FNNs)**: Standard neural networks where information flows in *one* *direction*
* **Convolutional Neural Networks (CNNs)**: Specialized for *image* processing
* **Recurrent Neural Networks (RNNs)**: Used for *sequential* data like text or time series
* **Deep Neural Networks (DNNs)**: Simply ANNs with many *hidden* *layers*

### Structure of a Standard Neural Network

A diagram of a network

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* **Input Layer**: *Receives* the initial data
* **Hidden Layers**: *Process* the information
* **Output Layer**: *Produces* the final result
* **Weights**: *Connections* between neurons that determine how information flows
* **Activation Functions**: Help the network *learn* *complex* *patterns*

### How Neural Networks Learn

1. ***Feedforward* Phase**:
   * Start with *input* data and initial random weights
   * Pass data through the network to get *predictions*
2. ***Backpropagation* Phase**:
   * Calculate the *error* between predictions and actual values
   * Adjust the *weights* to minimize this error
   * Use gradient descent to optimize the weights

## Convolutional Neural Networks (CNNs)

A diagram of a computer

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### What are CNNs?

* Specialized neural networks designed for *image processing*
* Can automatically detect features in images (edges, shapes, textures)
* Inspired by how the visual cortex in our *brain* works

### Main Components of a CNN

1. **Input Layer**: Accepts image data
2. **Convolutional Layer**: Applies filters to extract features
3. **Activation Function**: Introduces non-linearity
4. **Pooling Layer**: Reduces image size while keeping important information
5. **Fully Connected Layer**: Makes the final prediction

### Why CNNs are Powerful

* They can find patterns in images automatically
* They use parameter sharing (same filter used across the whole image)
* They focus on local regions, making them more efficient

## Computer Vision

### What is Computer Vision?

* Teaching computers to understand images and videos like humans do
* Allows computers to “see” and interpret the visual world
* Uses cameras (*passive* sensing) or devices like radar (*active* sensing)

### Computer Vision vs. Human Vision

* Humans see a cat as a fluffy animal
* Computers see a grid of numbers representing colors and shapes

### Key Components of Computer Vision

* **Camera**: Captures images
* **Lighting**: Affects image clarity
* **Computer**: Processes image data
* **Scene Interpretation**: Identifies what’s in the image

### Goals of Computer Vision

* Recognize objects and people
* Detect patterns
* Create virtual reality
* Enhance images
* Process visual information

### Real-World Applications

* **OCR**: Converting handwritten text to digital text
* **Medical Imaging**: Helping doctors analyze scans
* **Face Detection**: Recognizing faces in photos
* **Self-Driving Cars**: Helping vehicles “see” the road

### Core Problems in Computer Vision

1. **Reconstruction**: Building 3D models from 2D images
2. **Recognition**: Identifying objects in images

### Image Features

* **Features**: Numerical values that help understand important details in an image
* **Edges**: Lines where image brightness changes sharply
* **Texture**: Visible patterns or surface details
* **Regions**: Areas of an image grouped by similar properties