Day87_Recap_of_ML_DL_and_NLP_B4_GenAI

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1 AI Learning Journey

From today, I am starting my exploration into **Generative AI (GenAI)** and **Agentic AI**. But before we dive into these exciting areas, it's important to strengthen the foundation.

That's why I am first recapping some **essential theoretical concepts** from:
- **Machine Learning (ML)**
- **Deep Learning (DL)**
- **Natural Language Processing (NLP)**

This recap will help :

- Revisit the key fundamentals I have already learned.
- Connect these concepts to the bigger picture of GenAI and Agentic AI.
- Build a strong base to understand advanced applications.

  Let's get started with the recap!

2 List of Concepts to Recap

2.1 Machine Learning

1. What is Machine Learning?
2. Types of Machine Learning
   - Supervised Learning
   - Unsupervised Learning
   - Reinforcement Learning
3. Key ML Concepts
   - Training vs Test Data
   - Overfitting & Underfitting
   - Bias-Variance Tradeoff

- Evaluation Metrics

2.2 Deep Learning

1. What is Deep Learning?

2. Neural Network Basics
   - Neuron (Perceptron)
   - Activation Functions
   - Forward & Backward Propagation

3. Types of Neural Networks
   - Feedforward Neural Network (FNN)
   - Convolutional Neural Network (CNN)
   - Recurrent Neural Network (RNN)
   - Transformers

4. Key DL Concepts
   - Epochs, Batches, Iterations
   - Learning Rate
   - Regularization
   - Loss Functions

2.3 Natural Language Processing (NLP)

1. What is NLP?

2. Core NLP Tasks

3. Traditional NLP vs DL-based NLP

4. Modern NLP with Transformers

2.4 Comparison

- Machine Learning vs Deep Learning

2.5 Why This Matters for AI & Agents

3 Machine Learning Recap

3.1 What is Machine Learning?

Machine Learning (ML) is the science of making computers **learn from data** without being explicitly programmed.
Instead of writing rules, we feed data and let the computer **discover patterns** to make predictions or decisions.

> Example: Predicting house prices based on location, size, and number of rooms.

3.2 Types of Machine Learning

1. Supervised Learning
- Learn from **labeled data** (input + correct output given).
- Goal: predict outcomes for new inputs.
- Examples:
- Predicting exam scores from study hours.
- Spam detection in emails.
- Algorithms: Linear Regression, Logistic Regression, Decision Trees, Random Forests, SVM, Neural Networks.

2. Unsupervised Learning
- Learn from **unlabeled data** (no correct output).
- Goal: find hidden patterns or groups.
- Examples:
- Customer segmentation for marketing.
- Market basket analysis (products often bought together).
- Algorithms: K-Means, Hierarchical Clustering, PCA.

3. Reinforcement Learning (RL)
- Learn by **trial and error** with rewards or penalties.
- Agent interacts with environment → improves decisions over time.
- Examples:
- Self-driving cars.
- AlphaGo beating human champions.

3.3 Key ML Concepts

3.3.1 Training vs Test Data

- **Training Data** → used to teach the model.
- **Test Data** → used to check how well the model generalizes.

3.3.2 Overfitting & Underfitting

- **Overfitting** → model memorizes training data (bad for new data).

- **Underfitting** → model too simple, fails to capture patterns.

3.3.3 Bias-Variance Tradeoff

- **High Bias** → oversimplified, underfits.
- **High Variance** → too complex, overfits.
- Goal: balance bias & variance.

3.3.4 Evaluation Metrics

- Regression → RMSE, MAE, R^2
- Classification → Accuracy, Precision, Recall, F1-Score, AUC

4 Deep Learning Recap

4.1 What is Deep Learning?

- Subset of ML using **Neural Networks** with multiple layers.
- Handles **complex data** like images, text, audio.
- Inspired by how the human brain processes information.

4.2 Neural Network Basics

4.2.1 Neuron (Perceptron)

- Fundamental unit of a neural network.
- Takes inputs → multiplies with weights → adds bias → applies activation → outputs result.

Formula:

$$y = f(\Sigma(w_i x_i) + b)$$

4.2.2 Activation Functions

- Decide whether a neuron should activate.
- Common functions:
  - **Sigmoid** → outputs between 0–1 (good for probabilities).
  - **ReLU** → most widely used, avoids vanishing gradients.
  - **Softmax** → multi-class classification.

4.2.3 Forward Propagation

- Data flows **input → hidden layers → output**.

4.2.4 Backward Propagation (Backprop)

- Adjusts weights using **Gradient Descent** to reduce errors.

4.3 Types of Neural Networks

4.3.1 Feedforward Neural Network (FNN)

- Simplest form, data flows forward only.

4.3.2 Convolutional Neural Network (CNN)

- Specially designed for **images and spatial data**.

4.3.3 Recurrent Neural Network (RNN)

- Best for **sequential data** (time series, speech, text).

4.3.4 Transformers

- Advanced architecture for **NLP & AI Agents**.
- Powers modern LLMs like GPT, BERT.

4.4 Key DL Concepts

4.4.1 Epochs, Batches, Iterations

- **Epoch** → one full pass through training data.
- **Batch** → subset of training data used in one iteration.
- **Iteration** → one update step using a batch.

4.4.2 Learning Rate

- Controls step size in optimization.
- Too high → unstable.
- Too low → very slow learning.

4.4.3 Regularization

- Prevents overfitting.
- Techniques: Dropout, L2 Regularization, Batch Normalization.

4.4.4 Loss Functions

- Measure how wrong predictions are.
- Regression → MSE, MAE
- Classification → Cross-Entropy

5 Natural Language Processing (NLP)

5.1 What is NLP?

NLP (Natural Language Processing) is the branch of AI that focuses on enabling computers to **understand, interpret, and generate human language**.
It is the core of chatbots, translation apps, voice assistants, and modern **GenAI systems**.

5.2 Core NLP Tasks

- **Text Preprocessing** → Tokenization, Stopword Removal, Stemming, Lemmatization
- **Sentiment Analysis** → Understanding emotions in text (positive/negative/neutral)
- **Named Entity Recognition (NER)** → Identifying entities like names, dates, locations
- **Machine Translation** → Translating text between languages
- **Text Summarization** → Creating concise versions of long texts
- **Question Answering** → Answering queries from documents
- **Language Generation** → Generating human-like responses (LLMs)

5.3 Traditional NLP vs DL-based NLP

- **Traditional NLP**
  - Relied on rules and statistical models (Bag-of-Words, TF-IDF, n-grams).
  - Worked on small text tasks but struggled with context and meaning.
- **Deep Learning-based NLP**
  - Uses embeddings (Word2Vec, GloVe, FastText).
  - Captures semantic meaning of words.
  - Can handle context better.

5.4 Modern NLP with Transformers

- Transformers introduced **Attention Mechanism**, which allows models to focus on important words in context.

- Examples: BERT, GPT, T5.
- Powers today's **chatbots, search engines, summarizers, AI Agents**.

6 Machine Learning vs Deep Learning

Feature	Machine Learning	Deep Learning
Data Requirement	Small/Medium datasets	Large datasets
Feature Engineering	Manual	Learns automatically
Algorithms	Regression, SVM, Trees	Neural Networks (CNN, RNN, Transformers)
Training Time	Fast	Slow, needs GPU
Interpretability	Easier	Harder ("black box")

7 Why This Matters for AI & Agents

- **AI Agents** need **decision-making** ability (ML) + **complex data understanding** (DL) + **language interaction (NLP)**.
- Examples:
  - A stock-trading agent → uses **ML regression/classification**.
  - A vision-based agent (robot) → uses **DL (CNNs)** for image understanding.
  - A conversational agent → uses **NLP with Transformers** to understand and generate language.

  That's why ML, DL, and NLP fundamentals are essential before diving into **GenAI** and **Agentic AI**.

8 Key Takeaways

- **Machine Learning** teaches systems to learn patterns from data.
- **Deep Learning** uses neural networks to capture complex, high-dimensional patterns.
- **NLP** enables computers to understand and generate human language.
- Together, ML + DL + NLP provide the foundation for building **powerful AI Agents**.