# 🤖 Artificial Intelligence (AI), Machine Learning (ML), NLP, LLM & Generative AI – Summary Notes

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## 🧠 Artificial Intelligence (AI)

Artificial Intelligence (AI) is the branch of computer science focused on building systems that can perform tasks that typically require human intelligence.
These include reasoning, learning, perception, language understanding, and decision-making.

**Key Types of AI:**

1. **Narrow AI (Weak AI):**
    - Performs a specific task (e.g., chatbots, recommendation systems).
    - Examples: Siri, Google Assistant, ChatGPT.
2. **General AI (Strong AI):**
    - Can perform any intellectual task a human can.
    - Still theoretical and not yet achieved.
3. **Super AI:**
    - Exceeds human intelligence; a future concept involving advanced cognitive abilities.

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## ⚙️ Machine Learning (ML)

Machine Learning (ML) is a subset of AI that enables systems to learn patterns from data and improve over time without being explicitly programmed.

**Types of Machine Learning:**

1. **Supervised Learning:**
    - Trained using labeled data (input → output).
    - Example algorithms: Linear Regression, Decision Trees, Random Forest.
2. **Unsupervised Learning:**
    - Works with unlabeled data to find patterns.
    - Example algorithms: K-Means Clustering, PCA.
3. **Reinforcement Learning:**
    - Agent learns by interacting with an environment and receiving feedback (rewards/punishments).
    - Used in robotics and gaming.

**Key ML Concepts:**

- **Feature Engineering:** Selecting the right input variables.
- **Overfitting/Underfitting:** Balancing between memorizing and generalizing data.
- **Model Evaluation Metrics:** Accuracy, Precision, Recall, F1-score, ROC-AUC.

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### 🗣️ Natural Language Processing (NLP)

NLP is a subfield of AI focused on enabling computers to understand, interpret, and generate human language.

**Core Tasks in NLP:**

1. **Text Classification:** Categorizing text (e.g., spam detection).
2. **Named Entity Recognition (NER):** Identifying people, places, or organizations.
3. **Sentiment Analysis:** Determining if a statement is positive, negative, or neutral.
4. **Machine Translation:** Converting text between languages (e.g., Google Translate).
5. **Question Answering & Chatbots:** Powering conversational AI systems.

**NLP Techniques:**

- **Tokenization:** Splitting text into words or sentences.
- **Stemming/Lemmatization:** Reducing words to their root form.
- **Word Embeddings:** Representing words numerically (Word2Vec, GloVe, BERT embeddings).

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### □ Large Language Models (LLMs)

LLMs are powerful deep learning models trained on massive text datasets to understand and generate human-like language.

**Examples:**

- **OpenAI:** GPT-3, GPT-4
- **Google:** FLAN-T5, PaLM
- **Meta:** LLaMA
- **Mistral, Falcon, Zephyr, etc.**

**How LLMs Work:**

1. **Tokenization:** Converts text into numerical tokens.
2. **Transformer Architecture:** Uses self-attention to understand context between words.
3. **Pretraining:** Model learns general language patterns.
4. **Fine-tuning:** Model adapts to specific tasks (e.g., summarization, Q&A).

**LLM Capabilities:**

- Text generation
- Summarization
- Translation
- Code generation
- Conversational AI

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### ⚡ Retrieval-Augmented Generation (RAG)

RAG is a hybrid approach combining **information retrieval + generation**.

**Workflow:**

1. Retrieve relevant documents from a knowledge base using embeddings (FAISS/ChromaDB).
2. Feed those documents into an LLM.
3. Generate context-aware answers.

**Advantage:**
RAG avoids hallucinations and gives factual, document-based responses — exactly how your project works.

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### 🎨 Generative AI (GenAI)

Generative AI refers to systems that can **create new content** — text, images, music, or video — by learning from existing data.

**Examples:**

- **Text:** ChatGPT, Claude, Bard
- **Images:** DALL·E, Midjourney, Stable Diffusion
- **Video:** Runway, Pika Labs

- **Code:** GitHub Copilot, Code Llama

**Applications:**

- Content creation
- Design and marketing
- Game development
- Personalized tutoring systems
- Synthetic data generation

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**Key Libraries & Tools**

| Category | Library | Description |
|---|---|---|
| ML | Scikit-learn | Classical machine learning models |
| DL | TensorFlow, PyTorch | Deep learning frameworks |
| NLP | NLTK, spaCy, Transformers | Text preprocessing & modeling |
| LLM | LangChain, Hugging Face | Model orchestration & deployment |
| VectorDB | FAISS, ChromaDB | Document retrieval |
| UI | Streamlit | Interactive AI dashboards |

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**Future of AI & GenAI**

- Integration of **multimodal AI** (text + image + audio + video)
- Advancements in **reasoning and explainability**
- Ethical AI and data privacy frameworks
- AI-driven automation in healthcare, education, and software development

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**Summary:**

| Field | Focus | Example |
|---|---|---|
| AI | Simulates human intelligence | Self-driving cars |
| ML | Learns from data | Spam detection |
| NLP | Understands language | Chatbots |
| LLM | Generates language | GPT, FLAN-T5 |
| GenAI | Creates new content | DALL·E, ChatGPT |

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**End of Notes – By Chandan's DocuMind AI System**