FOUNDATIONS OF ARTIFICIAL INTELLIGENCE

A Practical Introduction for Learning, Testing, and Reasoning

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Page 1 – Introduction to Artificial Intelligence

Artificial Intelligence (AI) is a branch of computer science that focuses on building systems capable of performing tasks that normally require human intelligence. These tasks include reasoning, learning, problem-solving, perception, and language understanding.

The term Artificial Intelligence was first introduced by John McCarthy in 1956 during the Dartmouth Conference. Since then, AI has evolved from simple rule-based systems to advanced machine learning and deep learning models.

AI systems can be broadly classified into: - Narrow AI: Designed for a specific task (e.g., spam filtering) - General AI: Capable of performing any intellectual task a human can do (still theoretical)

AI is widely used in healthcare, finance, transportation, education, and research.

Page 2 – Types of AI Systems

AI systems are generally divided into three types:

1. Reactive Machines These systems do not store memories or past experiences. They respond only to current inputs. Example: IBM Deep Blue chess computer.

2. Limited Memory Systems These systems use past data for decision-making. Example: Self-driving cars that analyze recent traffic data.

3. Theory of Mind and Self-Aware AI These are conceptual models involving emotions, beliefs, and self-awareness. These systems do not yet exist in practice.

Most modern AI applications fall under Limited Memory Systems.

Page 3 – Machine Learning Basics

Machine Learning (ML) is a subset of AI that allows systems to learn patterns from data instead of being explicitly programmed.

Types of machine learning: - Supervised Learning: Uses labeled data - Unsupervised Learning: Finds patterns in unlabeled data - Reinforcement Learning: Learns via rewards and penalties

Machine learning models improve as the volume and quality of data increase.

Page 4 – Mathematical Concepts in ML

Machine learning relies heavily on mathematics.

Example: Mean Calculation Given values: 2, 4, 6, 8 Mean = (2 + 4 + 6 + 8) / 4 = 5

Example: Accuracy Formula Accuracy = Correct Predictions / Total Predictions

If a model makes 80 correct predictions out of 100: Accuracy = 80 / 100 = 0.8 = 80%

Page 5 – Deep Learning Overview

Deep Learning is a subset of machine learning based on neural networks with multiple layers.

A neural network consists of: - Input Layer - Hidden Layers - Output Layer

Deep learning enables breakthroughs in image recognition, speech recognition, and language understanding.

Page 6 – Natural Language Processing

Natural Language Processing (NLP) allows machines to understand and generate human language.

Key NLP tasks include: - Tokenization - Named Entity Recognition - Sentiment Analysis - Text Summarization

Modern NLP uses transformer-based models and attention mechanisms.

Page 7 – Retrieval-Augmented Generation

Retrieval-Augmented Generation (RAG) combines document retrieval with language generation.

RAG workflow: 1. Documents are stored in a vector database 2. Relevant chunks are retrieved 3. The language model generates grounded answers

RAG improves factual accuracy and reduces hallucinations.

Page 8 – Vector Databases and Embeddings

Embeddings are numerical representations of text capturing semantic meaning.

Vector databases such as ChromaDB allow similarity search using cosine distance.

Vector search retrieves relevant information even without exact keyword matches.

Page 9 – Agent-Based AI Systems

Agent-based systems consist of autonomous components called agents.

Each agent has: - A goal - Memory - Decision logic

Multi-agent systems improve reliability and scalability.

Page 10 – Conclusion

Artificial Intelligence continues to evolve rapidly.

Future AI systems will be more transparent, reliable, and privacy-preserving.

Understanding AI foundations is essential for building safe and scalable intelligent systems.