Applied Artificial intelligence

Master 1

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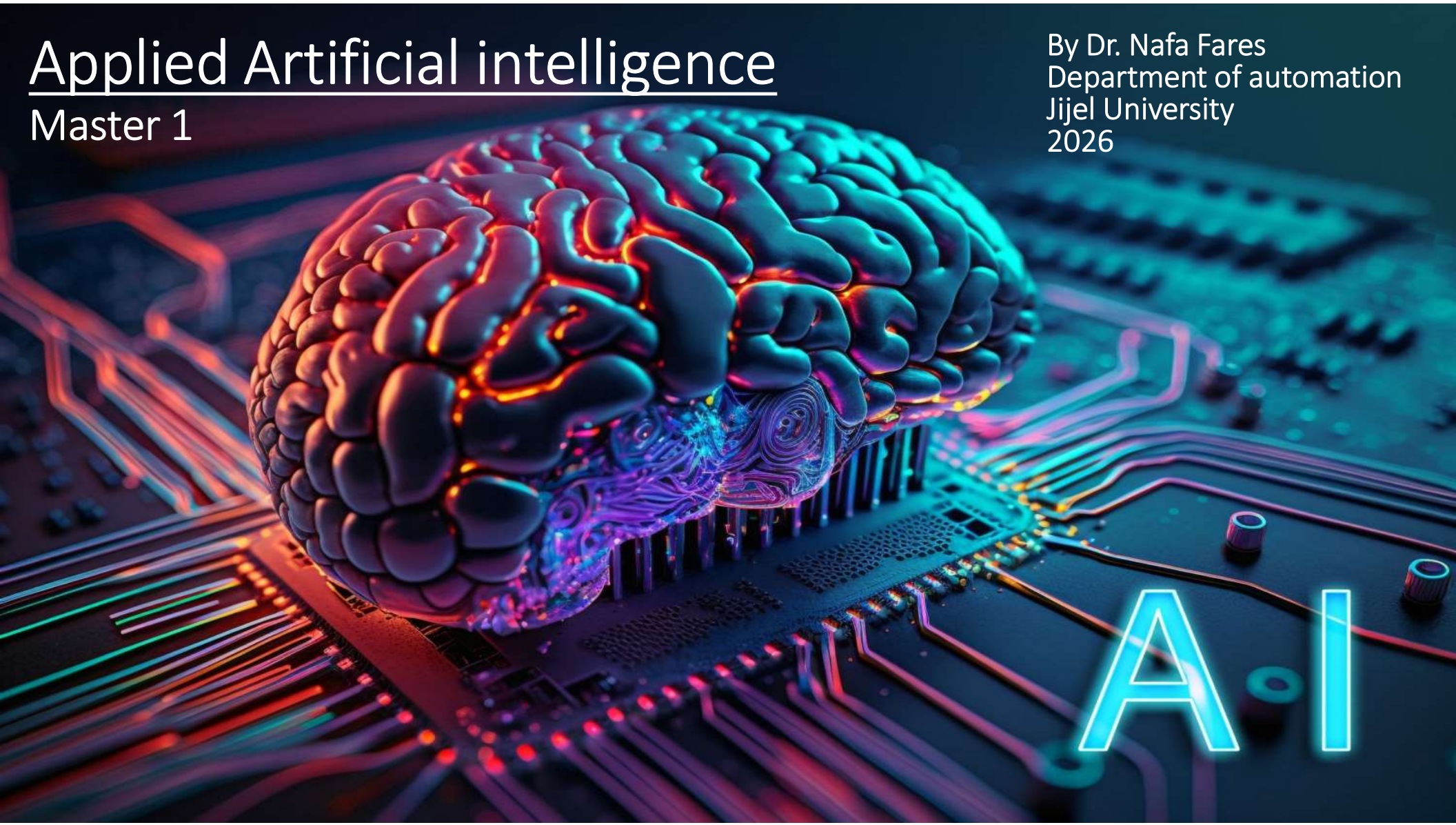
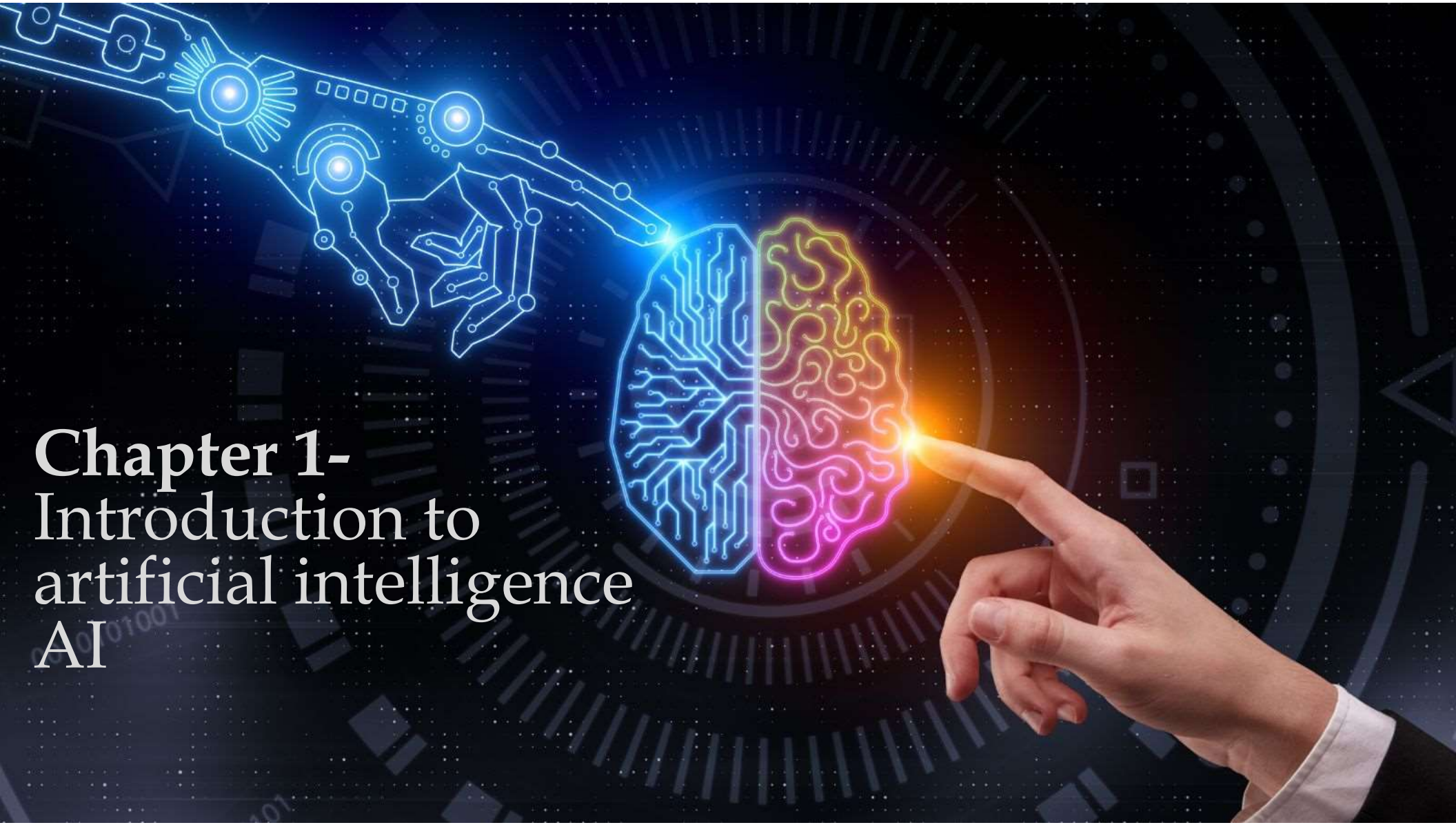




Chapter 1-
Introduction to artificial intelligence AI

Preface

In 2026, Artificial Intelligence (AI) has transitioned from an experimental discipline to the core infrastructure of modern software development, scientific research, and enterprise operations. For a Master's student, this course serves as a bridge between foundational theory and the practical engineering of intelligent systems.

- **The Evolution of the Field**

AI is no longer just a set of disconnected algorithms; it is an integrated science centered on the study of **intelligent agents** that perceive their environment and take actions to achieve specific goals.

Agentic AI: By 2026, the focus has shifted toward autonomous systems capable of multi-step reasoning and independent task execution.

AI-Native Development: Instead of retrofitting AI into existing systems, new applications are now designed with AI at their core.

- **Why This Course Matters for Graduate Students**
- Pursuing a Master's degree in AI provides a critical competitive advantage as the job market increasingly demands expertise in **Large Language Model (LLM) integration**, **MLOps**, and **responsible model design**.
- **Bridging Research and Industry:** Graduate study offers a unique space to choose between applied industry projects or deep research labs, both of which are essential for career paths in 2026.
- **Addressing Complexity:** While basic AI tools have become more accessible, the ability to build, optimize, and secure complex neural networks remains a high-level skill set.
- **Core Themes for 2026**

This course is structured to address the most significant trends shaping the current landscape:

- **Generative & Agentic AI:** Moving beyond simple chatbots to systems that can plan and execute workflows independently.
- **Ethical Governance:** As AI becomes ubiquitous, professionals must be equipped to handle bias detection, data privacy, and regulatory compliance.
- **Interdisciplinary Collaboration:** Effective AI solutions now require insights from cognitive psychology, linguistics, and policy studies.
- **A Call to Mastery**

This course helps students to move from being a user of AI to an architect of it. The ultimate goal is to foster a "creative-first" mindset where AI handles repetitive data tasks, freeing you to focus on the human-centric aspects of innovation: imagination, moral judgment, and complex problem-solving

1. Overview of AI

Since the invention of computers or machines, their capability to perform various tasks went on growing exponentially. Humans have developed the power of computer systems in terms of their diverse working domains, their increasing speed, and reducing size with respect to time. A branch of Computer Science named Artificial Intelligence pursues creating the computers or machines as intelligent as human beings.

What is Artificial Intelligence?

According to the father of Artificial Intelligence John McCarthy, it is "The science and engineering of making intelligent machines, especially intelligent computer programs". Artificial Intelligence is a way of making a computer, a computer-controlled robot, or a software think intelligently, in the similar manner the intelligent humans think. AI is accomplished by studying how human brain thinks, and how humans learn, decide, and work while trying to solve a problem, and then using the outcomes of this study as a basis of developing intelligent software and systems.

Philosophy of AI

While exploiting the power of the computer systems, the curiosity of human, lead him to wonder, "Can a machine think and behave like humans do?" Thus, the development of AI started with the intention of creating similar intelligence in machines that we find and regard high in humans.

Goals of AI

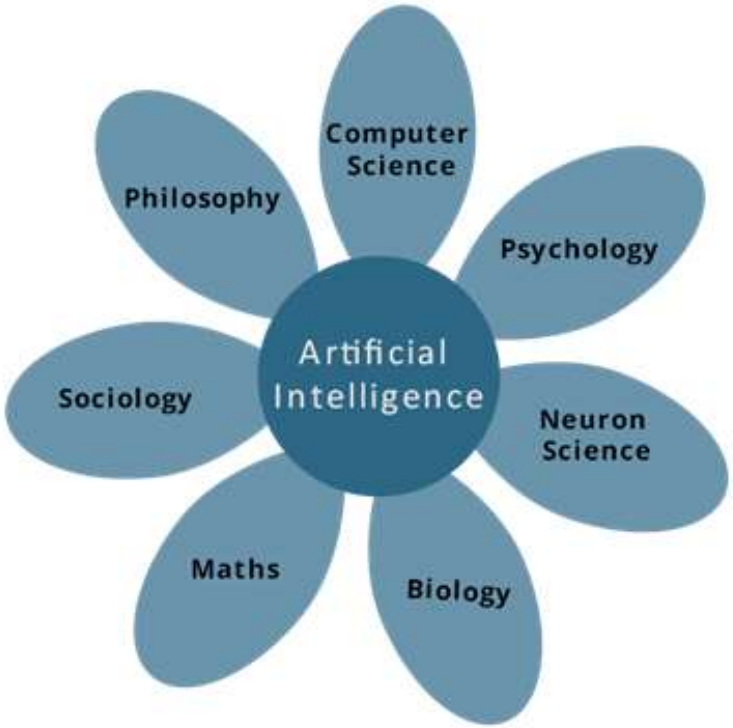
- To Create Expert Systems: The systems which exhibit intelligent behavior, learn, demonstrate, explain, and advice its users.

- To Implement Human Intelligence in Machines: Creating systems that understand, think, learn, and behave like humans.

1. Overview of AI

What Contributes to AI?

Artificial Intelligence Artificial intelligence is a science and technology based on disciplines such as Computer Science, Biology, Psychology, Linguistics, Mathematics, and Engineering. A major thrust of AI is in the development of computer functions associated with human intelligence, such as reasoning, learning, and problem solving. Out of the following areas, one or multiple areas can contribute to build an intelligent system.



1. Overview of AI

Applications of AI

AI has been dominant in various fields such as:

- **Gaming AI**

plays crucial role in strategic games such as chess, poker, tic-tac-toe, etc., where machine can think of large number of possible positions based on heuristic knowledge.

- **Natural Language Processing**

It is possible to interact with the computer that understands natural language spoken by humans.

- **Expert Systems**

There are some applications which integrate machine, software, and special information to impart reasoning and advising. They provide explanation and advice to the users.

- **Vision Systems** These systems understand, interpret, and comprehend visual input on the computer. For example,
  - o A spying aeroplane takes photographs which are used to figure out spatial information or map of the areas.
  - o Doctors use clinical expert system to diagnose the patient.
  - o Police use computer software that recognizes the face of criminal with the stored portrait made by forensic artist

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1. Overview of AI

Applications of AI

 Handwriting Recognition
The handwriting recognition software reads the text written on paper by a pen or on screen by a stylus. It can recognize the shapes of the letters and convert it into editable text.
 Intelligent Robots
Robots are able to perform the tasks given by a human. They have sensors to detect physical data from the real world such as light, heat, temperature, movement, sound, bump, and pressure. They have efficient processors, multiple sensors and huge memory, to exhibit intelligence. In addition, they are capable of learning from their mistakes and they can adapt to the new environment.

Core Technologies

- **Machine Learning (ML)**: Systems learn from data to find patterns and make decisions.
- **Deep Learning (DL)**: A subset of ML using neural networks for complex tasks like image recognition.
- **Natural Language Processing (NLP)**: Enables machines to understand and generate human language.

Types of AI

- **Narrow AI (Weak AI)**: Excels at specific tasks (e.g., chess, speech recognition).
- **General AI (AGI)**: Hypothetical AI with human-level intelligence across all tasks.
- **Superintelligence (ASI)**: Hypothetical AI surpassing human intelligence.

1. Overview of AI

History of AI

Here is the history of AI during 20th century:

Year	Milestone / Innovation
1923	Karel Čapek's play named "Rossum's Universal Robots" (RUR) opens in London, first use of the word "robot" in English.
1943	Foundations for neural networks laid.
1945	Isaac Asimov, a Columbia University alumni, coined the term Robotics.
1950	Alan Turing introduced Turing Test for evaluation of intelligence and published Computing Machinery and Intelligence. Claude Shannon published Detailed Analysis of Chess Playing as a search.
1956	John McCarthy coined the term Artificial Intelligence. Demonstration of the first running AI program at Carnegie Mellon University.
1958	John McCarthy invents LISP programming language for AI.
1964	Danny Bobrow's dissertation at MIT showed that computers can understand natural language well enough to solve algebra word problems correctly.
1965	Joseph Weizenbaum at MIT built ELIZA, an interactive problem that carries on a dialogue in English.
1969	Scientists at Stanford Research Institute Developed Shakey, a robot, equipped with locomotion, perception, and problem solving.

1. Overview of AI

History of AI

Year	Milestone / Innovation
1973	The Assembly Robotics group at Edinburgh University built Freddy, the Famous Scottish Robot, capable of using vision to locate and assemble models.
1979	The first computer-controlled autonomous vehicle, Stanford Cart, was built.
1985	Harold Cohen created and demonstrated the drawing program, Aaron.
1990	Major advances in all areas of AI: □ Significant demonstrations in machine learning □ Case-based reasoning □ Multi-agent planning □ Scheduling □ Data mining, Web Crawler □ natural language understanding and translation □ Vision, Virtual Reality □ Games
1997	The Deep Blue Chess Program beats the then world chess champion, Garry Kasparov.
2000	Interactive robot pets become commercially available. MIT displays Kismet, a robot with a face that expresses emotions. The robot Nomad explores remote regions of Antarctica and locates meteorites.

1. Overview of AI

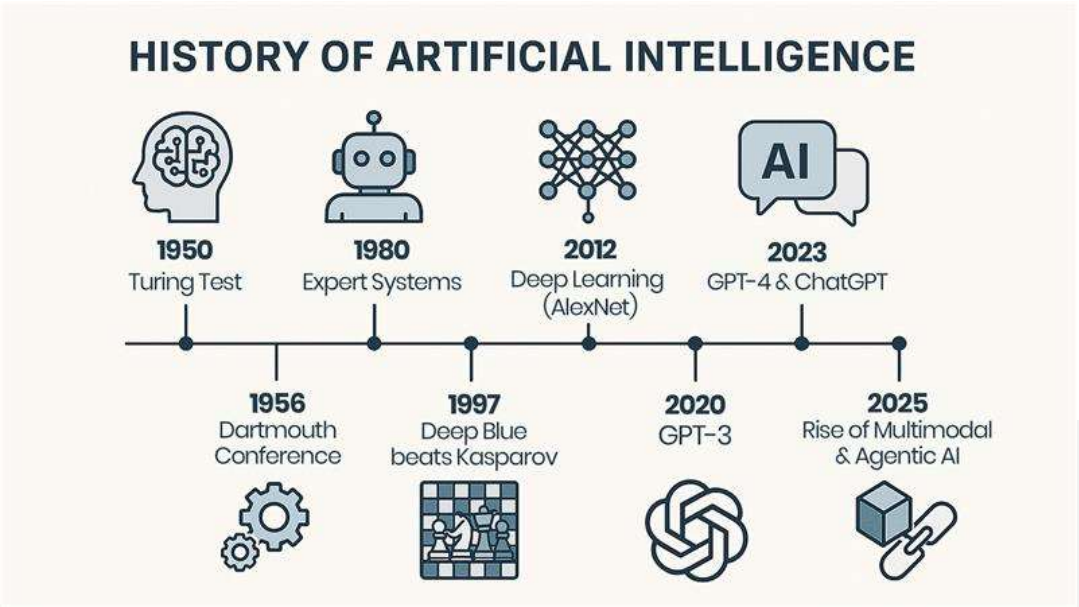
History of AI

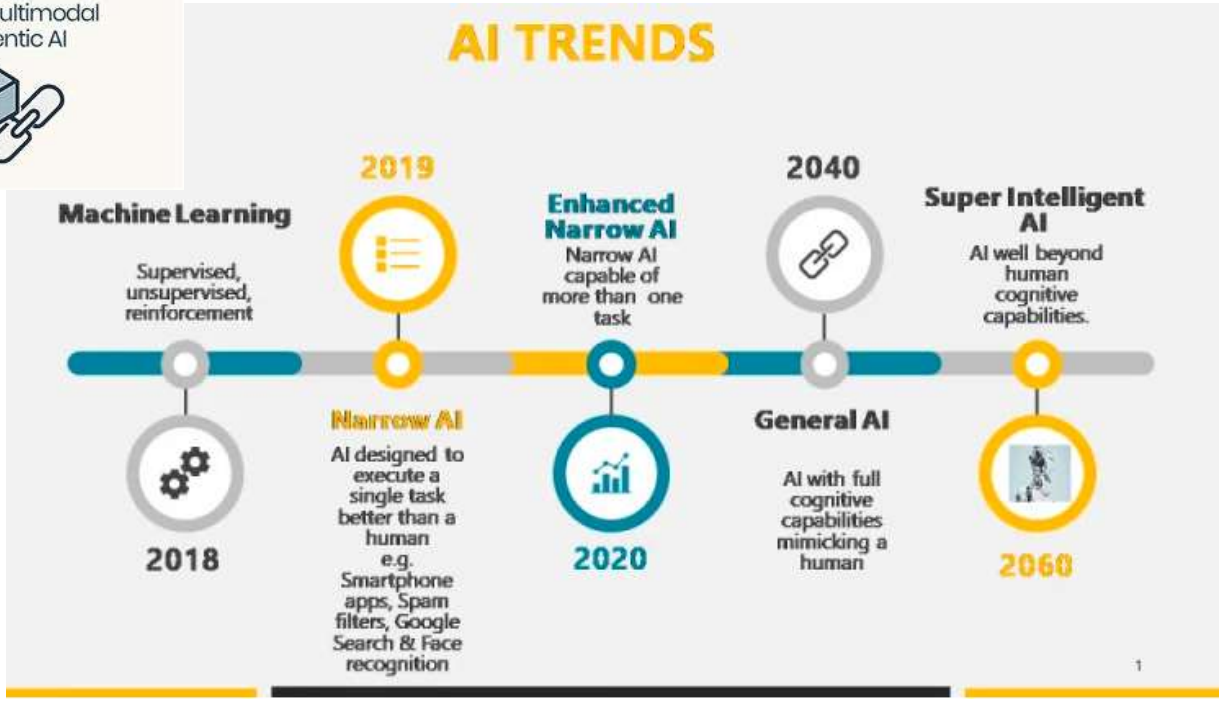
Year	Milestone / Innovation
Early 2000s	Increased computing power (GPUs), vast data from the internet, and better algorithms (especially neural nets) revive AI.
2011	IBM's Q/A system, Watson, defeated two former champions on the quiz show *Jeopardy!*, demonstrating advancements in natural language understanding.
2012	AlexNet's success in the ImageNet competition, leveraging Convolutional Neural Networks (CNNs) and GPUs, brought deep learning to the forefront and dramatically increased progress in image recognition.
2016	Google DeepMind's AlphaGo defeated Go champion Lee Sedol, a game considered more complex than chess for AI due to its intuitive nature.
2017	The introduction of the transformer architecture revolutionized natural language processing and became the foundation for modern large language models.
2020's-present	The release of advanced models like OpenAI's GPT-3, DALL-E, and ChatGPT (in late 2022) ushered in an era of rapid progress in creating human-like text, images, and other content, reaching a broad public audience

Deep Learning & Modern AI (2010s - Present)

- **Deep Learning Boom:** Advancements in neural networks enable breakthroughs in computer vision and natural language processing (NLP).
- **Generative AI:** Models like GANs and transformers (e.g., ChatGPT, Google Gemini) create realistic content, transforming industries from healthcare to finance.
- **Future:** Focus shifts towards ethical AI, addressing bias, privacy, and the long-term goal of Artificial General Intelligence (AGI).

1. Overview of AI





2. Machine learning

• Introduction

Machine learning is a branch of Artificial Intelligence (AI) and computer science which focuses on the use of data and algorithms to imitate the way that humans learn, gradually improving its accuracy. We live in the age of data, where everything around us is connected to a data source, and everything in our lives is digitally recorded.

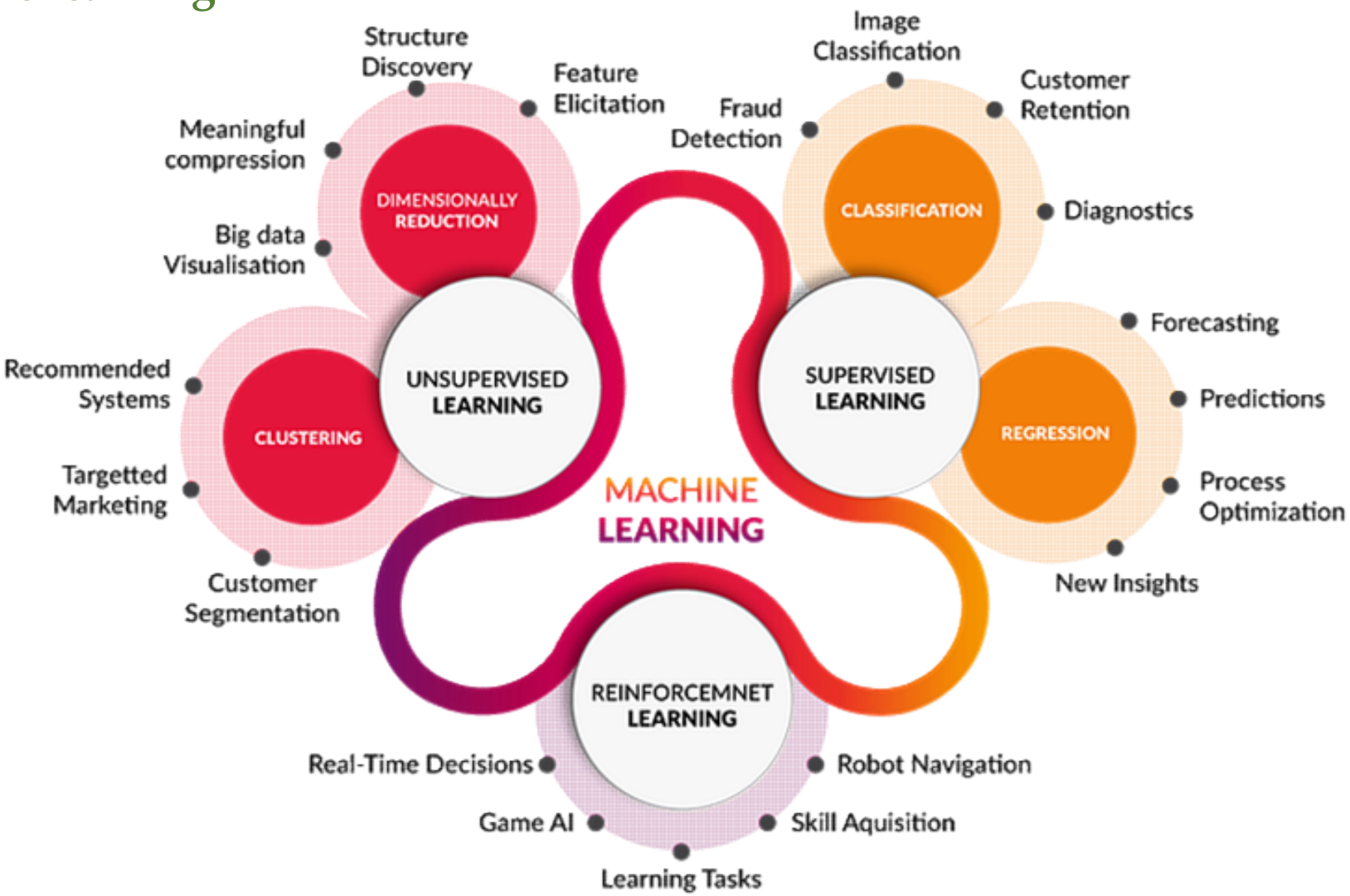
For instance, the current electronic world has a wealth of various kinds of data, such as the Internet of Things (IoT) data, cybersecurity data, smart city data, business data, smartphone data, social media data, health data, COVID-19 data, and many more.

Machine learning is an exciting field of study and one that impacts and will continue to impact our lives as strongly as other technologies have. Machine learning is incredibly complex and how it works varies depending on the task and the algorithm used to accomplish it.

However, at its core, a machine learning model is a computer looking at data and identifying patterns, and then using those insights to better complete its assigned task. Any task that relies upon a set of data points or rules can be automated using machine learning, even those more complex tasks such as responding to customer service calls and reviewing resumes.

The four major machine learning models are supervised learning, unsupervised learning, semi-supervised learning, and reinforcement learning

2. Machine learning

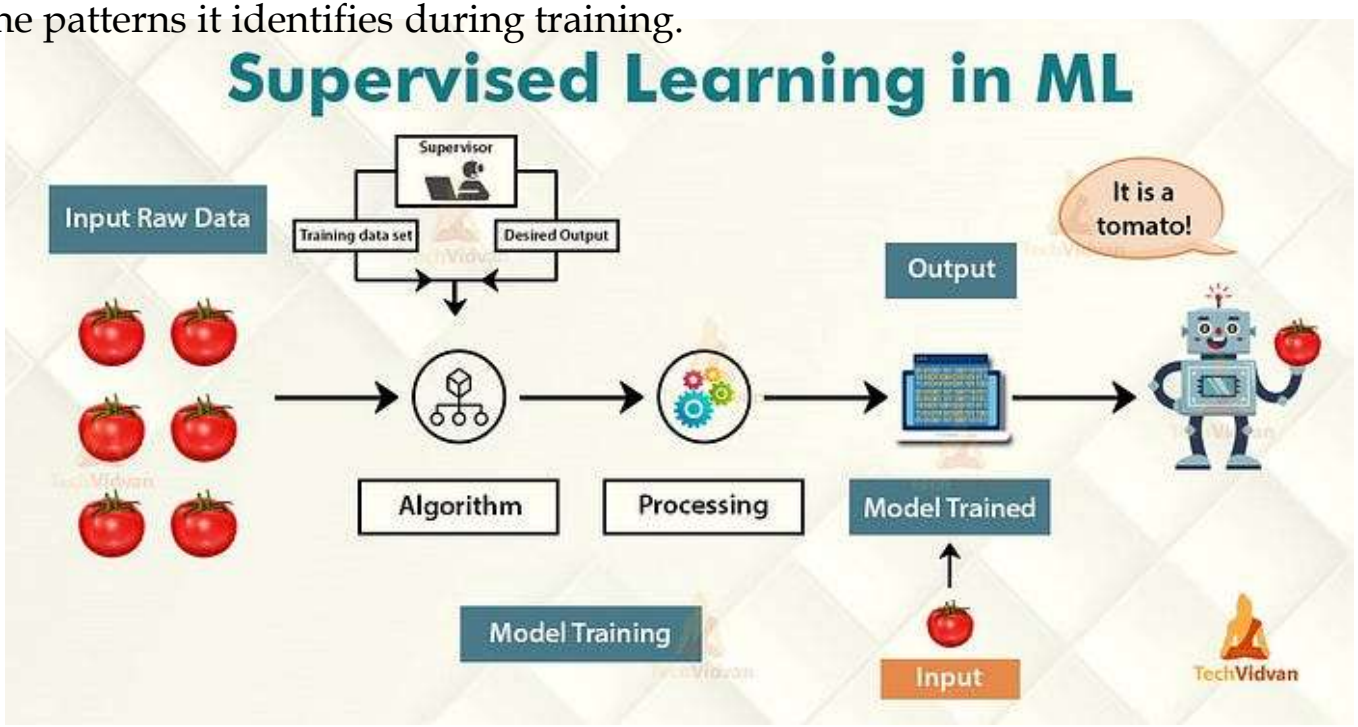


2. Machine learning

The primary types of machine learning are **supervised learning, unsupervised learning, and reinforcement learning**. **Semi-supervised learning** and **generative AI** are also recognized categories that combine aspects of the main types or represent a distinct application approach.

Supervised Learning

In supervised learning, models are trained on a labeled dataset, which means both the input data and the corresponding correct output (label) are provided. The algorithm learns to map inputs to outputs and makes predictions based on the patterns it identifies during training.



2. Machine learning

Supervised Learning

- **Classification**

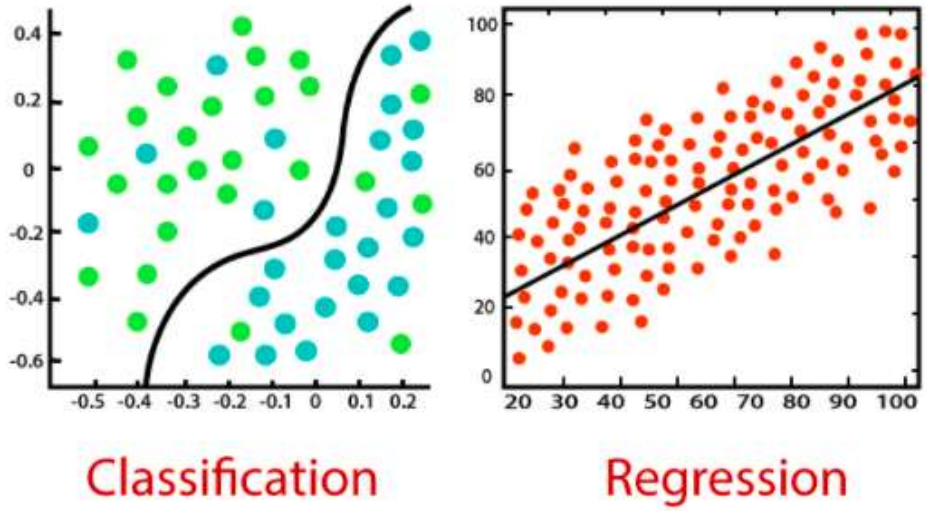
  Predicts a categorical output (e.g., whether an email is "spam" or "not spam", or the type of animal in an image). Classification is a process of finding a function which helps in dividing the dataset into classes based on different parameters. In Classification, a computer program is trained on the training dataset and based on that training, it categorizes the data into different classes

- **Regression**

  Regression is a process of finding the correlations between dependent and independent variables. It helps in predicting a continuous numerical value (e.g., forecasting house prices, stock values, or temperature).

There are some very practical applications of supervised learning algorithms in real life, including:

- Text categorization
- Face Detection
- Signature recognition
- Customer discovery
- Spam detection
- Weather forecasting



2. Machine learning

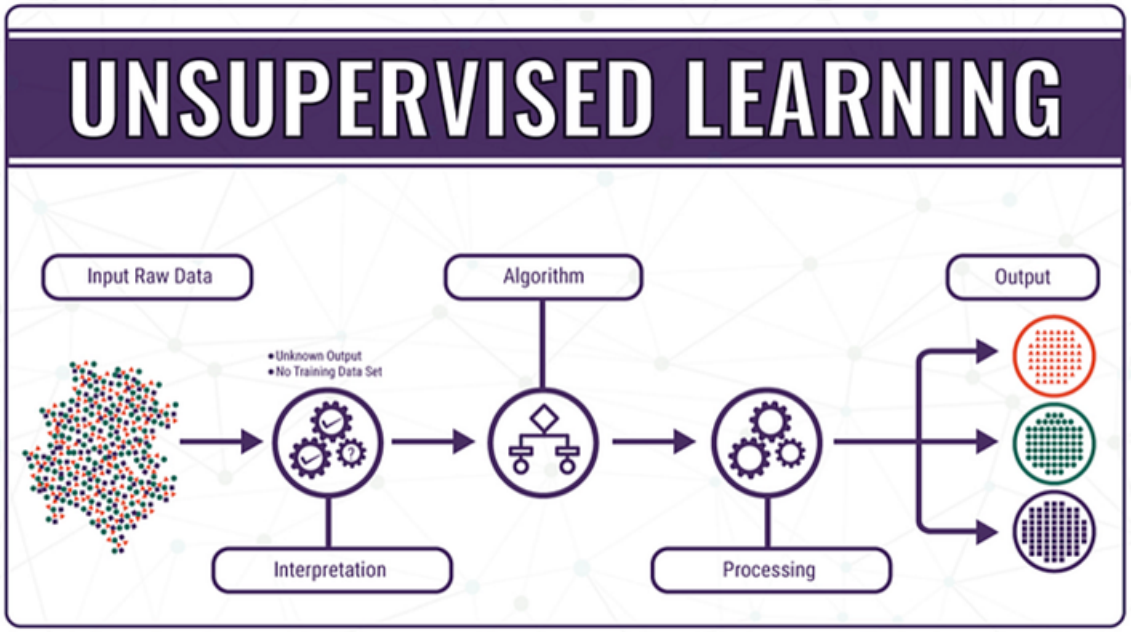
Unsupervised Learning

Unsupervised learning deals with unlabeled data. The goal of the algorithm is to discover hidden patterns, structures, or relationships within the data on its own without human guidance or predefined answers.

- **Clustering:** Groups similar data points together based on their inherent characteristics (e.g., customer segmentation for marketing purposes).
- **Dimensionality Reduction:** Reduces the number of features in a dataset while retaining important information, often to simplify the model and reduce processing time (e.g., Principal Component Analysis, or PCA).
- **Anomaly Detection:** Identifies rare items or outliers in a dataset (e.g., spotting unusual financial transactions for fraud detection).

Some practical applications of unsupervised learning algorithms include:

- Fraud detection
- Malware detection
- Identification of human errors during data entry
- Conducting accurate basket analysis, etc.



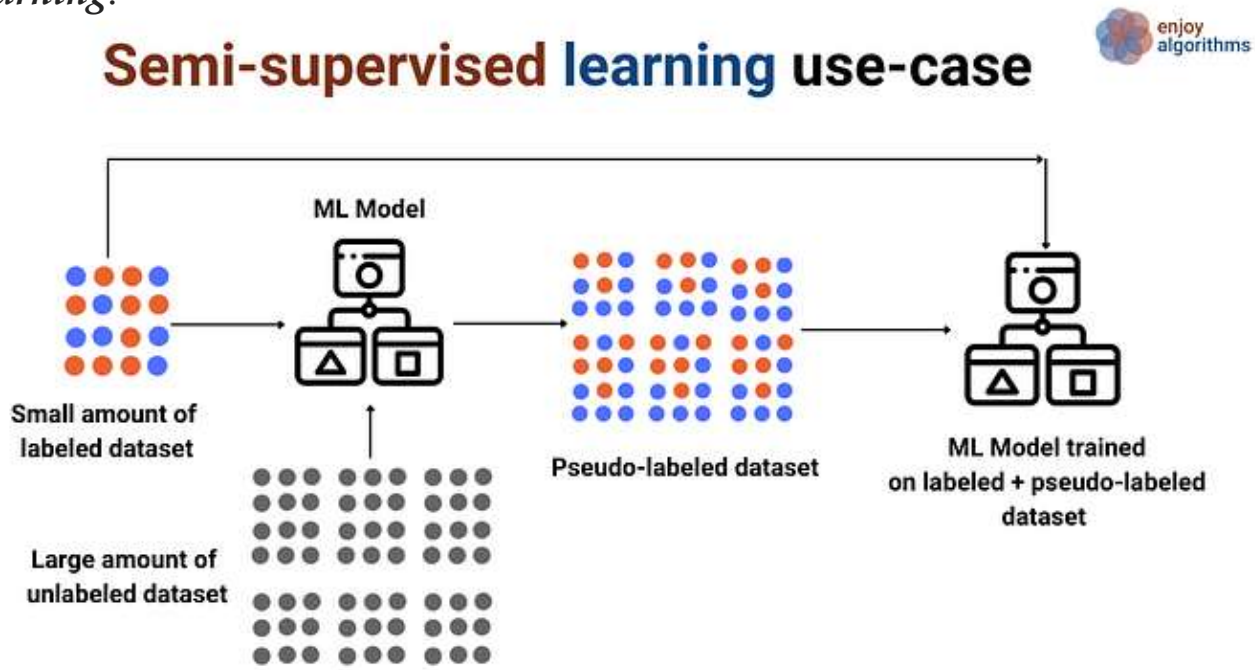
2. Machine learning

Semi-Supervised Learning

Semi-supervised learning is a hybrid approach that uses a small amount of labeled data combined with a large amount of unlabeled data for training.
This is particularly useful when labeling data is time-consuming or expensive, providing a balance between accuracy and cost.

Practical applications of Semi-Supervised Learning:

- Speech Analysis
- Internet Content Classification
- Protein Sequence Classification

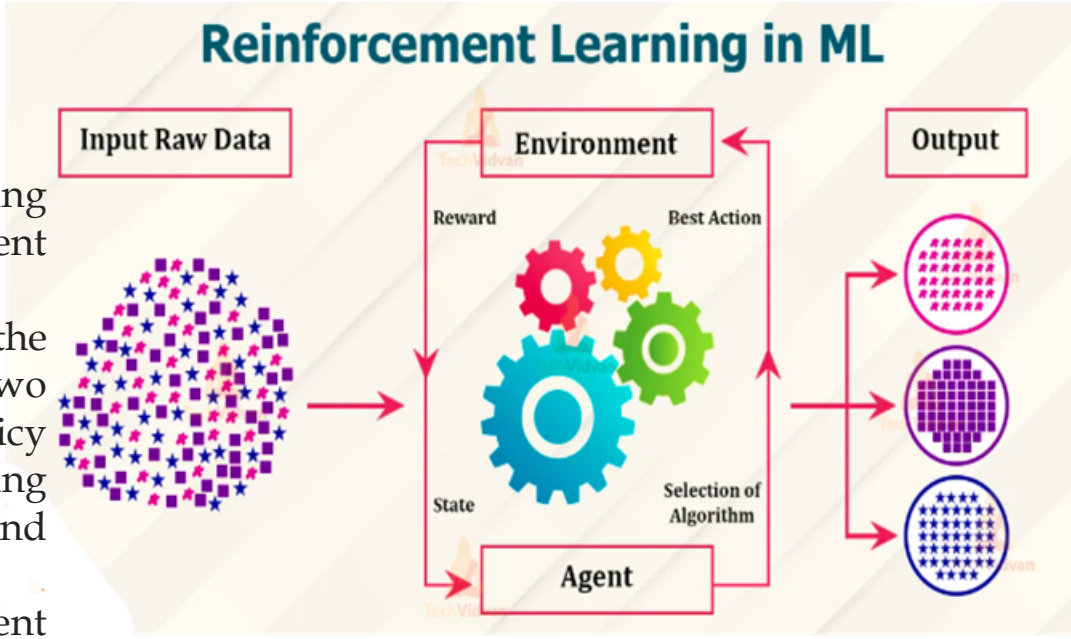


2. Machine learning

Reinforcement Learning

Reinforcement learning involves training an agent to make a sequence of decisions through trial and error. The agent interacts with an environment and receives feedback in the form of rewards for desirable actions and penalties for undesirable ones. The goal is for the agent to learn the optimal strategy or "policy" to maximize its cumulative reward over time. This is commonly used in:

- Robotics and automation.
- Autonomous vehicles.
- Game AI (e.g., training an AI to play chess or Go).



There are 3 types of reinforcement learning algorithms:

1.Q-learning: The most important reinforcement learning algorithm is Q-learning and it computes the reinforcement for states and actions.

2.Policy iteration: Policy iteration computes the reinforcement for states and actions by following two steps i.e., policy evaluation step followed by policy improvement step. In this reinforcement learning algorithm, there is an agent and a domain of states and actions.

3.Value iteration: Value iteration computes reinforcement for states and actions by using reinforcement signal determined by reinforcement function.

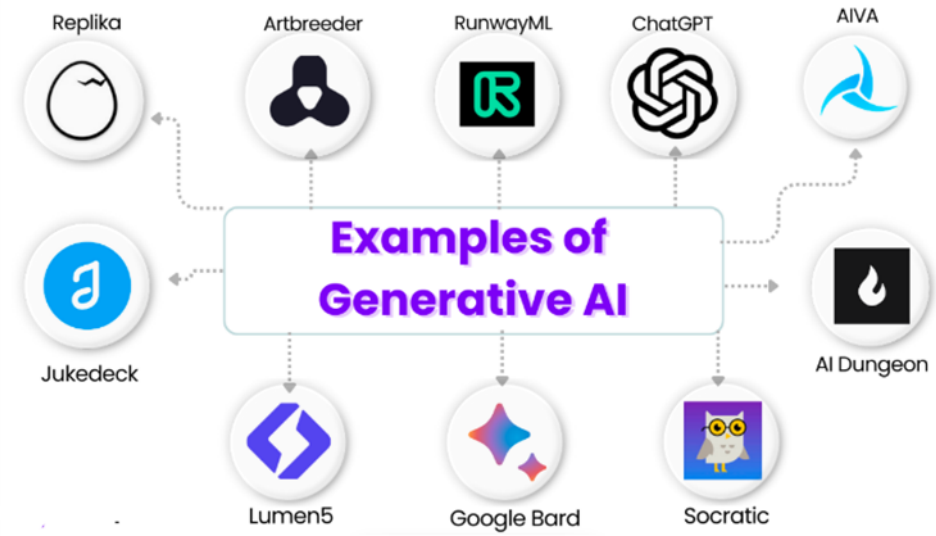
2. Machine learning

Reinforcement Learning

Real-life examples of Reinforcement Learning:
•Data Centre automated cooling using Deep RL
•Personalized product recommendation system
•Ad recommendation system
•Personalized video recommendations
•Customized action in video games
•Personalized chatbot response
•AI-powered stock buying/selling

Generative AI

Generative AI refers to algorithms, such as neural networks, that can create new content, from text and images to music and beyond, by learning from existing data. In business, it revolutionizes product development and customer experiences. Payment systems leverage generative AI for fraud detection and personalized financial services. In marketing, it enables hyper-personalized content, automating ad creation, and optimizing campaign strategies. This technology is transforming industries by enhancing efficiency and innovation.



3. Deep learning

Definition

Deep learning is a subset of machine learning driven by multilayered neural networks whose design is inspired by the structure of the human brain. Deep learning models power most state-of-the-art artificial intelligence (AI) today, from computer vision and generative AI to self-driving cars and robotics.

Unlike the explicitly defined mathematical logic of traditional machine learning algorithms, the artificial neural networks of deep learning models comprise many interconnected layers of "neurons" that each perform a mathematical operation. By using machine learning to adjust the strength of the connections between individual neurons in adjacent layers—in other words, the varying model *weights* and *biases*—the network can be optimized to yield more accurate outputs. While neural networks and deep learning have become inextricably associated with one another, they are not strictly synonymous: "deep learning" refers to the training of models with at least 4 layers (though modern neural network architectures are often much "deeper" than that).

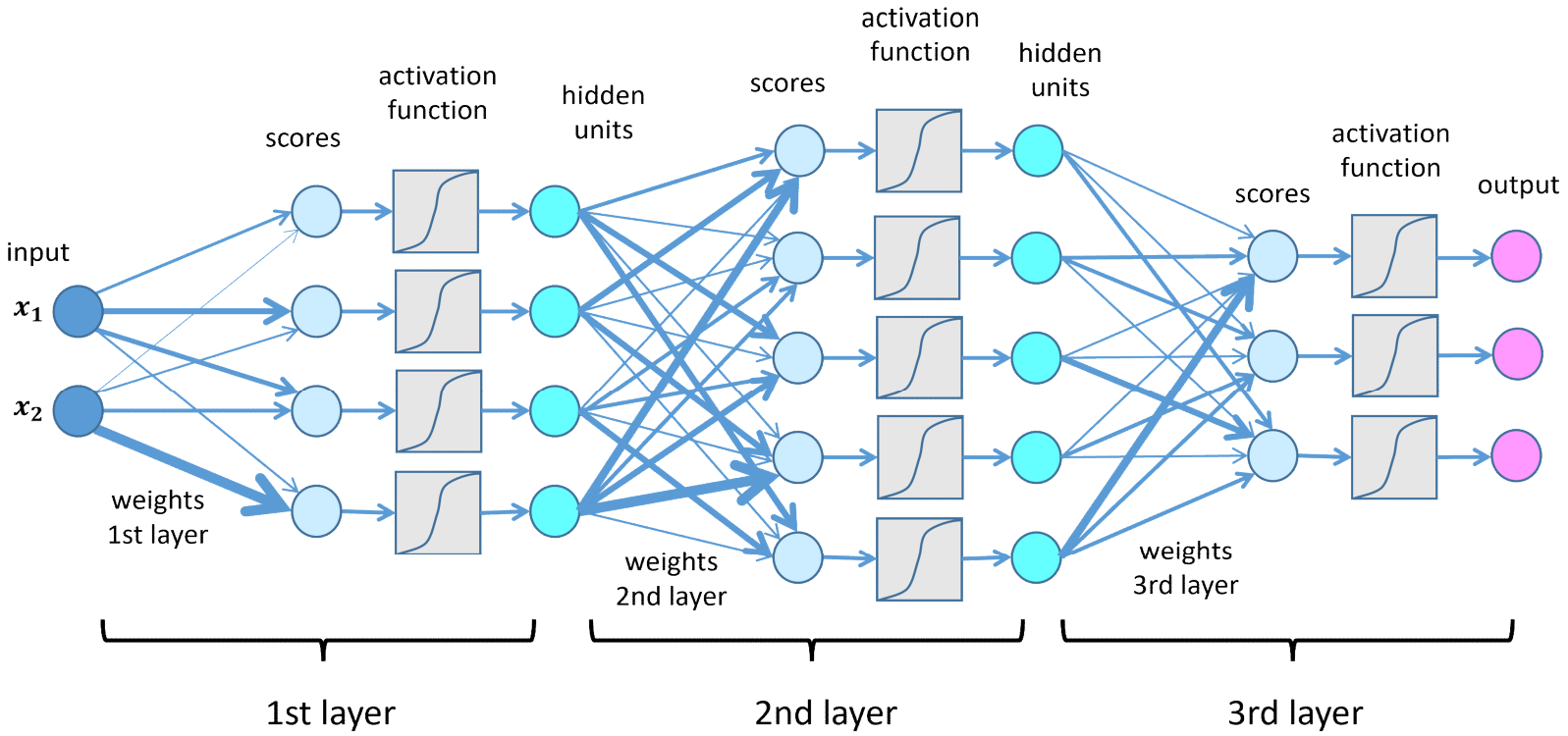
Deep learning types

Deep learning types are primarily defined by their neural network architectures, with key types including **Convolutional Neural Networks (CNNs)** for vision, **Recurrent Neural Networks (RNNs) & LSTMs** for sequences (text/speech), **Transformers** (advanced NLP/vision), **Generative Adversarial Networks (GANs)** for data creation, and **Autoencoders** for feature learning, all built on layered Artificial Neural Networks (ANNs).

3. Deep learning

How Deep Learning Works?

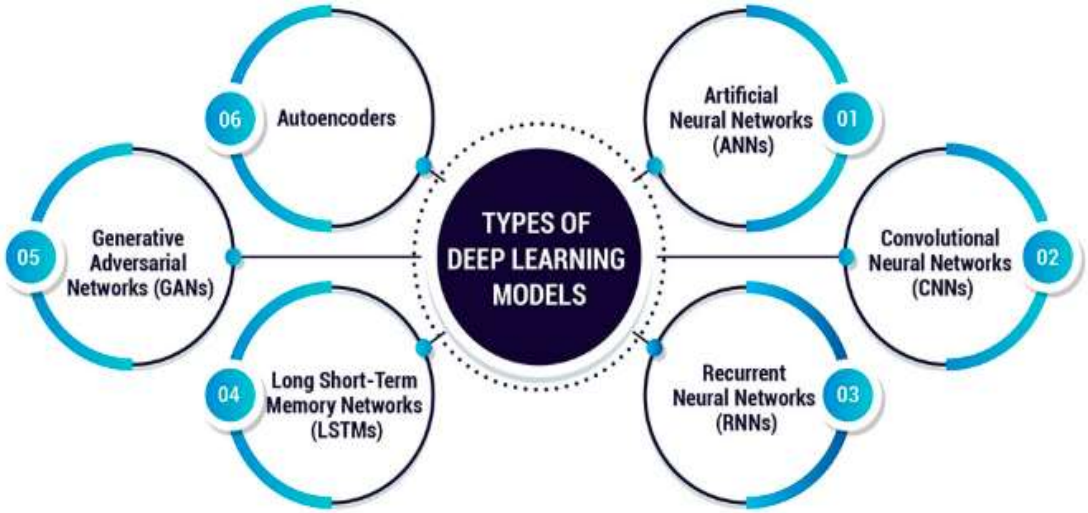
- Neural network consists of layers of interconnected nodes or neurons that collaborate to process input data. In a fully connected deep neural network data flows through multiple layers where each neuron performs nonlinear transformations, allowing the model to learn intricate representations of the data.
- In a deep neural network the input layer receives data which passes through hidden layers that transform the data using nonlinear functions. The final output layer generates the model's prediction.



3. Deep learning

Common Deep Learning Architectures

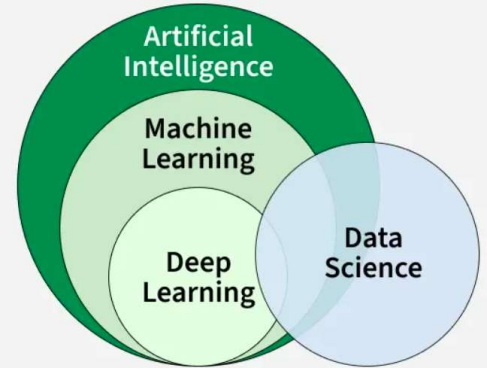
- **Convolutional Neural Networks (CNNs):** Excellent for grid-like data (images/video) by capturing spatial hierarchies, used in image recognition and object detection.
- **Recurrent Neural Networks (RNNs):** Process sequential data like text, speech, and time series by maintaining internal memory, used in NLP and speech recognition.
- **Long Short-Term Memory (LSTMs):** A specialized RNN variant that handles long-term dependencies in sequences, crucial for language modeling.
- **Transformers:** Modern architecture using self-attention, revolutionizing NLP (like GPT models) and increasingly used in computer vision.
- **Generative Adversarial Networks (GANs):** Consist of a generator and discriminator to create realistic new data, used for image synthesis and data augmentation.
- **Autoencoders:** Learn compressed representations (encodings) of data, used for dimensionality reduction and anomaly detection.
- **Deep Belief Networks (DBNs) & Restricted Boltzmann Machines (RBMs):** Earlier generative models, useful for feature learning and dimensionality reduction.
- **Multilayer Perceptrons (MLPs):** Foundational feedforward networks with input, hidden, and output layers, for general pattern recognition.



3. Machine learning vs Deep learning

Machine Learning (ML)

- **Approach:** Uses algorithms (like Regression, SVM) to find patterns in data, often requiring manual feature engineering.
- **Data:** Works well with smaller, structured datasets.
- **Hardware:** Can often run on standard CPUs.
- **Training:** Faster, from seconds to hours.
- **Interpretability:** More interpretable ("white box").
- **Use Cases:** Spam filtering, recommendation systems, predictive maintenance



Deep Learning (DL)

- **Approach:** Uses deep artificial neural networks (many layers) that learn features automatically (end-to-end).
- **Data:** Needs very large, often unstructured datasets (images, text, audio).
- **Hardware:** Requires powerful GPUs/TPUs due to complexity.
- **Training:** Longer, from hours to weeks.
- **Interpretability:** Often a "black box," less transparent.
- **Use Cases:** Image/face recognition, natural language processing (NLP), autonomous driving.