Chapter 9

Artificial intelligence and other applications

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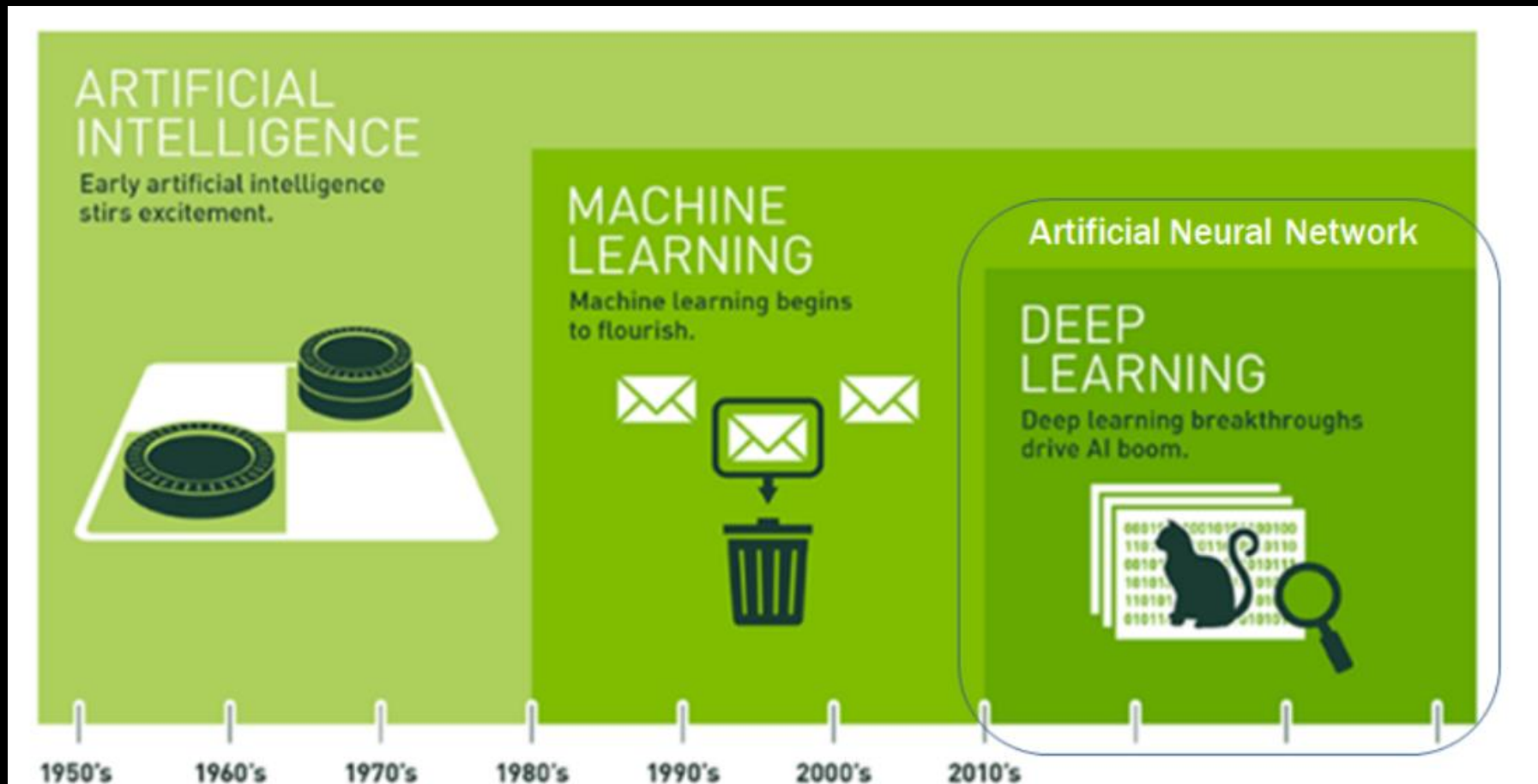
9.1 Artificial intelligence, machine learning, and deep learning

- **Artificial intelligence** (AI) refers to machines that have the intelligence to imitate human intelligence and perform complex tasks like humans.

- An important method for implementing the artificial intelligence is the machine learning models.

- Neural network is the most important model for artificial intelligence.

- One method for finding the solution to the neural network model is deep learning.

9.1 Artificial intelligence, machine learning, and deep learning

9.1 Artificial intelligence, machine learning, and deep learning

- Artificial Intelligence (AI) is a machine that thinks humanly and acts rationally.

- Level 1: Simple control machine – wash machine

- Level 2: Classical artificial intelligence has numerous and sophisticated ways to establish input-output relationships, utilizing a knowledge base

- Level 3: Artificial intelligence that accepts the machine learning models

- Level 4: When performing machine learning, the machine directly learns the features of the input values without a person inputting them.

9.1 Artificial intelligence, machine learning, and deep learning

❖ Artificial intelligence

- In 1974, Paul Warboss proposed a backpropagation algorithm that could solve multilayer neural networks.

    - character recognition and speech recognition.

- In 2006, Geoffrey Hinton announced the deep confidence neural network (deep learning)

    - capable of unsupervised learning, which was impossible.

- In 2012, Alex Krizhevsky and Ilya Sutskever built AlexNet

    - convolutional neural network - vision application.

9.1 Artificial intelligence, machine learning, and deep learning

❖ **Artificial intelligence**

- In 2016, Google DeepMind's AlphaGo popularized deep learning methods and showed results that surpassed human levels in several fields.

- AI research has continued to conduct innovative research to solve problems such as natural language processing and complex mathematical problems.

- In 2022, generative AI such as OpenAI's ChatGPT and Drawing AI was applied to actual personal hobbies and work applications.

- Generative AI led to theories of caution and threats to AI.

9.1 Artificial intelligence, machine learning, and deep learning

❖ **Technologies of artificial intelligence**

- Current AI comprises a neural network model in which numerous nodes have intelligence and perform their calculations.

- AI performs many simulations on a neural network with many hidden layers with various weights.

- When a question is given to AI, each node responds to the question and transmits a signal to the next node.

- Each node that receives the signal filters it according to its own criteria, the bias, and re-produces it.

- The sum of the filtered signals becomes the 'answer'.

9.1 Artificial intelligence, machine learning, and deep learning

❖ **Technologies of artificial intelligence**

- Maze exploration algorithm: robots, self-driving cars

- Fuzzy theory: natural language processing

- Pattern recognition: allows computers to judge data similarly to humans and distinguish what kind of data it is.

- Machine learning:

- Artificial neural network:

- Genetic algorithm:

9.1 Artificial intelligence, machine learning, and deep learning

❖ **Technologies of artificial intelligence**

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9.1 Artificial intelligence, machine learning, and deep learning

❖ **Energy and computer architecture issues of AI**

- Deep learning for AI is a simulation that takes a long time and consumes a lot of electricity for computer operation.

- Current computers are separated from the CPU, a serial processing device, to the data storage and processing lines and auxiliary data processing devices.

- This auxiliary data processing device refers to the graphic processing units (GPU) performing parallel processing.

- AI requires simultaneous calculations in each node, and the parallel processing device must be the main device.

9.1 Artificial intelligence, machine learning, and deep learning

❖ **Machine learning**

| Table 9.1.1 Comparison between a computer program and machine learning		
	Computer program	Machine learning
Input	A = 3, B = 2	coefficients 3, 2, 1, 8, 3, 5
Program	C = A * B	3 * X + 2 * Y = 1 8 * X + 3 * Y = 5
Output	C = 3 * 2 = 6	X = 1, Y = -1

9.1 Artificial intelligence, machine learning, and deep learning

❖ **Deep learning**

- Deep learning has been popular since 2010 because of several important events

1) Microsoft's voice recognition program.

2) In 2012, the University of Toronto's SuperVision team recorded an incredible error rate of 16.4% with AlexNet in the image recognition competition IMAGENET.

3) In 2012, Google successfully recognized cats and humans by learning from 10 million screens of captured YouTube videos using unsupervised learning.

9.1 Artificial intelligence, machine learning, and deep learning

❖ **Deep learning**
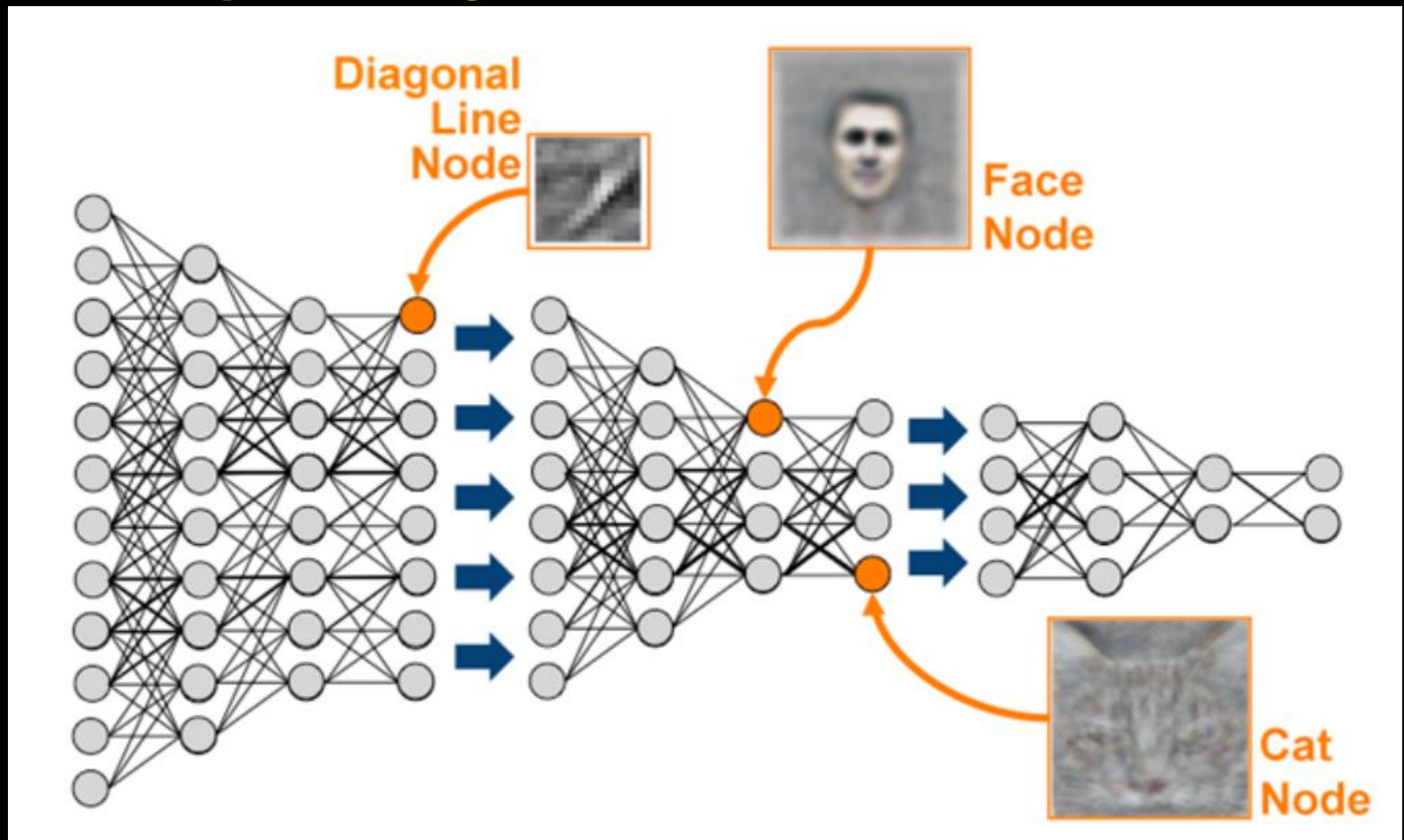
9.2 Text mining

- A method of searching for useful information in such text databases is called text mining.

- A traditional search method for useful information in text databases is keyword information retrieval.

- However, as the amount of digital documents increases, keyword search methods can cause users to be confused about which documents are useful.

- It became necessary to create measures of the importance or relevance of the documents being searched and to prioritize the information being searched.

9.2 Text mining

❖ Issues in text mining

A. Preprocessing of data for text mining

B. Measure of the appropriateness of information retrieval

$$\text{precision} = \frac{n(R \cap T)}{n(T)}$$

$$\text{recall} = \frac{n(R \cap T)}{n(R)}$$

C. Information retrieval method

 - similarity based search

$$d(x_1, x_2) = \frac{x_1 \cdot x_2}{||x_1|| ||x_2||}$$

9.3 Web data mining

- **Web data mining** tries to solve the following issues.

  - The web is constantly increasing and updating, so there is a problem with efficiently managing the web.

  - The web has a non-standardized structure, and the information that users want is a very small portion of the database, so there is a problem of efficient searching.

  - Most users do not have detailed network or search skills, so there is a problem with guiding them easily.

9.3 Web data mining

- **Web content mining** is similar to text mining, but it utilizes hyperlinks.

1) Search web pages for a given query to form a root set, and form a base set including all pages linked to the web pages in the root set. The pages in the base set are denoted as $\{1, 2, ..., n\}$, and the pages linked to each page are denoted as a $n \times n$ matrix $A = \{a_{ij}\}$. The element a_{ij} of the matrix is 1 if page i and page j are linked, and 0 if not.

2) Each page in the base set is given an initial weight $\boldsymbol{w} = (w_1, w_2, \ldots w_n = 1)$ and a hub weight $\boldsymbol{h} = (w_1, w_2, \ldots w_n = 1)$. At this time, the sum of the squares of the weights is set to 1, and the relationship between the two weights is defined as follows.

$$\boldsymbol{h} = A \cdot \boldsymbol{w}$$
$$\boldsymbol{w} = A'\boldsymbol{h}$$

The first equation means that if a page points to multiple trusted pages, its hub weight should increase. The next equation means that if a page is recommended by multiple hub pages, its weight should increase.

3) The above two equations are applied repeatedly l times, which can be mathematically expressed as follows.

$$\boldsymbol{h} = A \cdot \boldsymbol{w} = (AA') \cdot \boldsymbol{h} = (AA')^2 \cdot \boldsymbol{h} = \cdots = (AA')^l \cdot \boldsymbol{h}$$
$$\boldsymbol{w} = A' \cdot \boldsymbol{h} = (A'A) \cdot \boldsymbol{w} = (A'A)^2 \cdot \boldsymbol{w} = \cdots = (A'A)^l \cdot \boldsymbol{w}$$

That is, each weight is the eigenvector of $(AA')^l$ and $(A'A)^l$.

4) It searches pages with large weights and hub weights of each page first.

9.3 Web data mining

- Web page classification;
  - Classifying new pages using training pages consisting of pages already classified into specific topics.

- Weblog mining;
  - When a server accesses a web page and searches for information, it stores basic information such as IP address, requested URL, and requested time.
  - The amount of weblog data recorded can easily reach hundreds of terabytes, and analyzing this data is called web log mining.

9.4 Multimedia mining

- Similarity search for image data

- Classification of image data
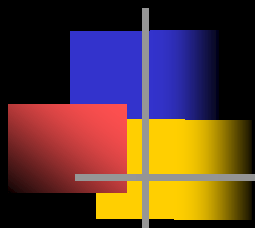
- Association analysis of image data

9.5 Spatial data analysis

- **Spatial data analysis** finds interesting patterns in a database containing spatial information.
  - Understand spatial data, discover spatial relationships, and discover relationships.
  - Widely used in medicine, transportation, the environment, the management of multinational companies, and geographic information systems.
- Spatial data often exists in various formats and different regions.
  - Create a data cube; multidimensional analysis can be used to facilitate spatial data analysis.

Summary

- Artificial intelligence, machine learning, neural network, and deep learning
- Text mining
- Web data mining
- Multimedia data mining
- Spatial data analysis

Thank you !!!