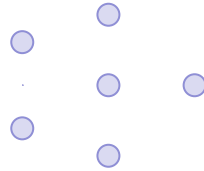


Artificial Intelligence

A-Level Computer Science ■ Topic 18

A-Level Computer Science



Artificial Intelligence

What we will cover

- 1 What AI is
- 2 Graphs in AI
- 3 Neural networks
- 4 ML, DL, RL, regression
- 5 Recap

1 What AI is

Three nested ideas

Artificial intelligence 人工智能 builds systems that do tasks normally needing human intelligence – speech, images, translation, games, driving, generating text.

Artificial intelligence

Machine learning – learn patterns from data

Deep learning – many-layer neural nets

AI, machine learning, deep learning

Each is a subset of the one before — deep learning is one way of doing machine learning, which is one way of doing AI.

Artificial Intelligence (AI)

machines do tasks that
normally need human intelligence

Machine Learning (ML)

systems learn patterns
from data, not by fixed rules

Deep Learning (DL)

many-layer
neural networks

2

Graphs

Many AI problems sit on a graph

Nodes 节点 are states or places; **edges** 边 are moves or relationships.

pathfinding

roads; shortest route – Dijkstra, A*

game playing

board positions; **mini-max** 极小化极大 with alpha-beta

state space

apply operators until you reach a goal

knowledge

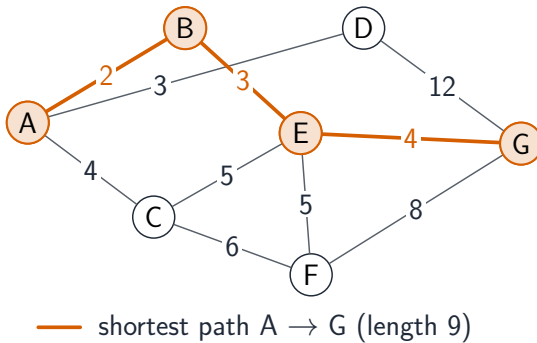
a **semantic network** 语义网络:
dog IS-A animal

Standard

tools: **BFS** 广度优先搜索 and **DFS** 深度优先搜索.

Shortest path on a graph

Weights are costs; Dijkstra keeps the cheapest known route to each node and improves it.



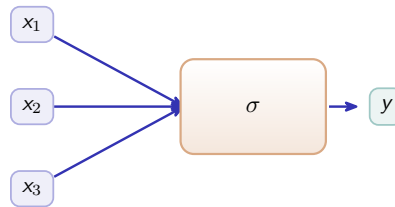
3

Neural networks

One artificial neuron

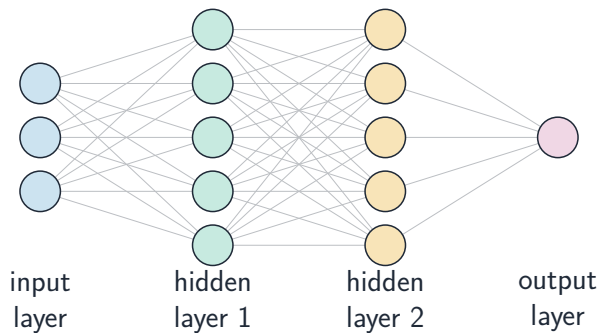
An **artificial neuron** 人工神经元:

- 1 multiply each **input** by a **weight** 权重
- 2 add them up with a **bias** 偏置项
- 3 apply an **activation function** 激活函数 (e.g. ReLU)
- 4 the output feeds the next layer



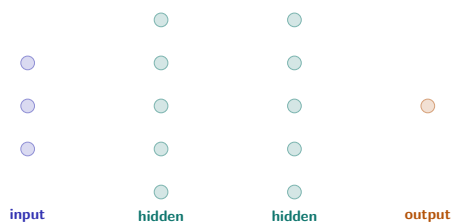
A layered network

Inputs feed hidden layers feed outputs; “deep” just means more than one hidden layer.



Layers: input, hidden, output

Neurons sit in layers. With many **hidden layers** 隐藏层 it is a **deep neural network** 深度神经网络.



ANNs learn patterns straight from raw data – pixels, audio, text – without hand-designed features.

Three kinds of learning

supervised

监督学习

data has **labels** 标签.
Learns input →
label. Classification
or regression.

unsupervised

无监督学习

no labels. Finds
structure – e.g. a
cluster 聚类 of
similar customers.

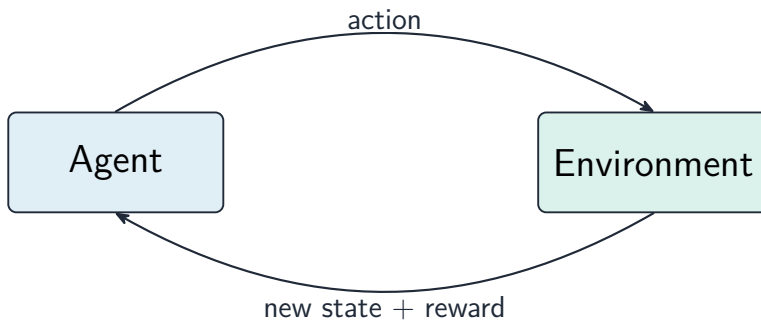
reinforcement

强化学习

an **agent** 智能体 acts,
gets a **reward** 奖励,
learns a **policy** 策略
by trial and error.

Reinforcement learning

The agent acts, the environment returns a state and a reward, and the policy is updated to earn more reward.



Deep learning vs reinforcement learning

Deep learning is ML with deep nets. Lower layers learn edges and phonemes; higher layers combine them. Needs **lots of data** and **lots of compute** (GPUs). For small datasets, simpler ML often wins.

Reinforcement learning: the agent sends an action; the environment returns a new state and a reward. Used for games, robot control, driving – sequential decisions, no labels up front.

Where it ends up



Perception, planning and control — each a learned model, all running together.

Training: backpropagation

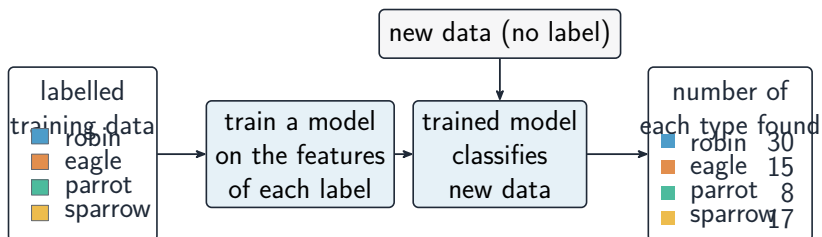
Training adjusts the **weights** so outputs match the targets –
backpropagation 反向传播 with **gradient descent** 梯度下降.

- 1 forward pass – input through to the output
- 2 compute the error with a **loss function** 损失函数
- 3 backward pass – each weight's gradient, via the chain rule
- 4 update the weights by a small **learning rate** 学习率

Repeat over many examples and many **epochs** 训练轮次. After training, a new input needs only one forward pass.

The training loop

Forward pass, compare with the label, propagate the error back, adjust the weights — repeated over the whole training set.



Regression predicts a number

Regression 回归 predicts a number (a house price, tomorrow's temperature).

Classification 分类 predicts a category.

Linear regression 线性回归 fits a line that minimises the sum of squared errors:

$$y = m_1x_1 + \dots + m_nx_n + c$$

Temperature or spam?

(a) tomorrow's temperature – a number $\Rightarrow$ **regression**, one output neuron.

(b) spam or not – a category $\Rightarrow$ **classification**, one probability per class.

Both are supervised.

4

Recap

Topic 18 – key takeaways

1 Nesting

DL $\subset$ ML $\subset$ AI

2 Neuron

weighted sum + bias + activation

3 Learning

supervised, unsupervised, reinforcement

4 Train

backprop adjusts weights to cut the loss

Check yourself

- 1 Is deep learning a kind of machine learning, or the other way round?
- 2 What does an activation function do?
- 3 An agent learns from reward, with no labels – which paradigm?
- 4 Predicting a house price: regression or classification?

Answers 1. DL is a kind of ML 2. adds non-linearity after the weighted sum 3. reinforcement learning 4. regression