COMP3057

Introduction to AI and ML

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27/5/2025

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Who is your lecturer?

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小红书

You can also find me in Xiao Hongshu!

Who is your TA?

- Au Ho Yin
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- Huang Xiufeng
  - xiufenghuang@life.hkbu.edu.hk, Year-3 Ph.D. student

How do we evaluate you?

- **Homework and Mini-Projects**
  - The majority of mini-projects and homework assignments are open-ended tasks without standard answers.
  - Your work will be evaluated based on its originality and compared with submissions from other students.
  - **Note:** Even if your submission runs correctly, it may not receive full marks if it lacks innovation.
- **Presentations**
  - We are considering whether to have a presentation for each mini-project.
- **Final examinations**: Paper-based format

What you will learn?

You will learn

Artificial Intelligence

What you will learn?

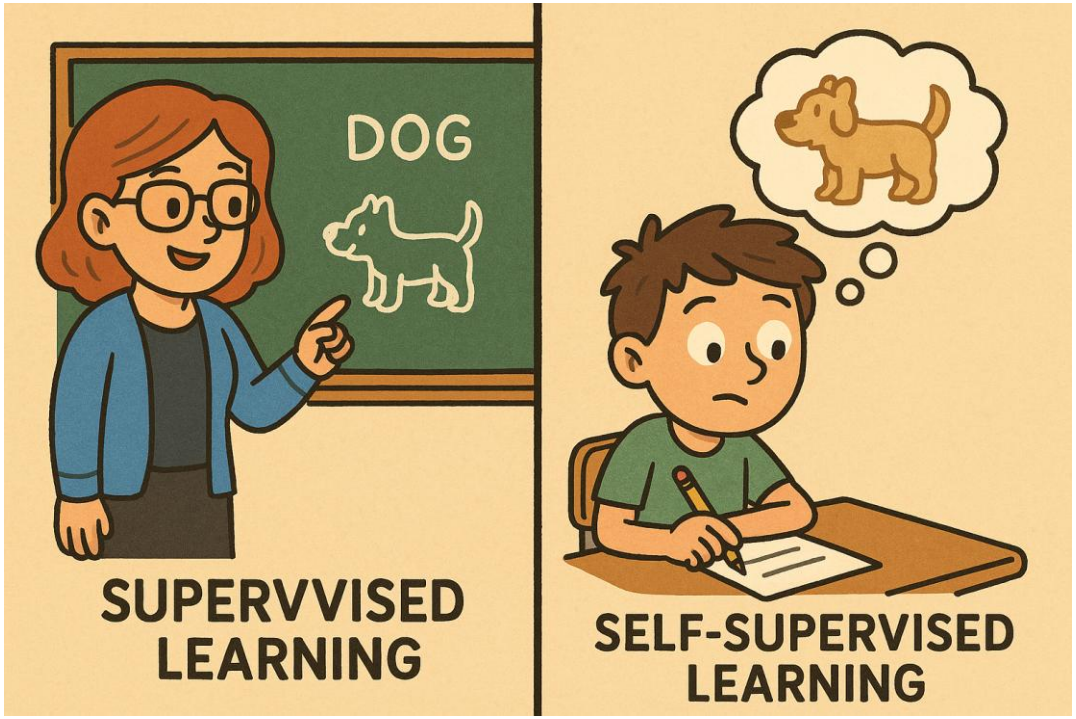
- **A**rtificial **I**ntelligence = AI

U.S. Secretary of Education under Trump mistakenly called **AI (Artificial Intelligence)** as **"A1."**

Never make this mistake after our class!!

What you will do in this class?

- Our whole class will be delivered in a **supervised-learning** mode.
- You need to do **self-supervised** learning on your own.



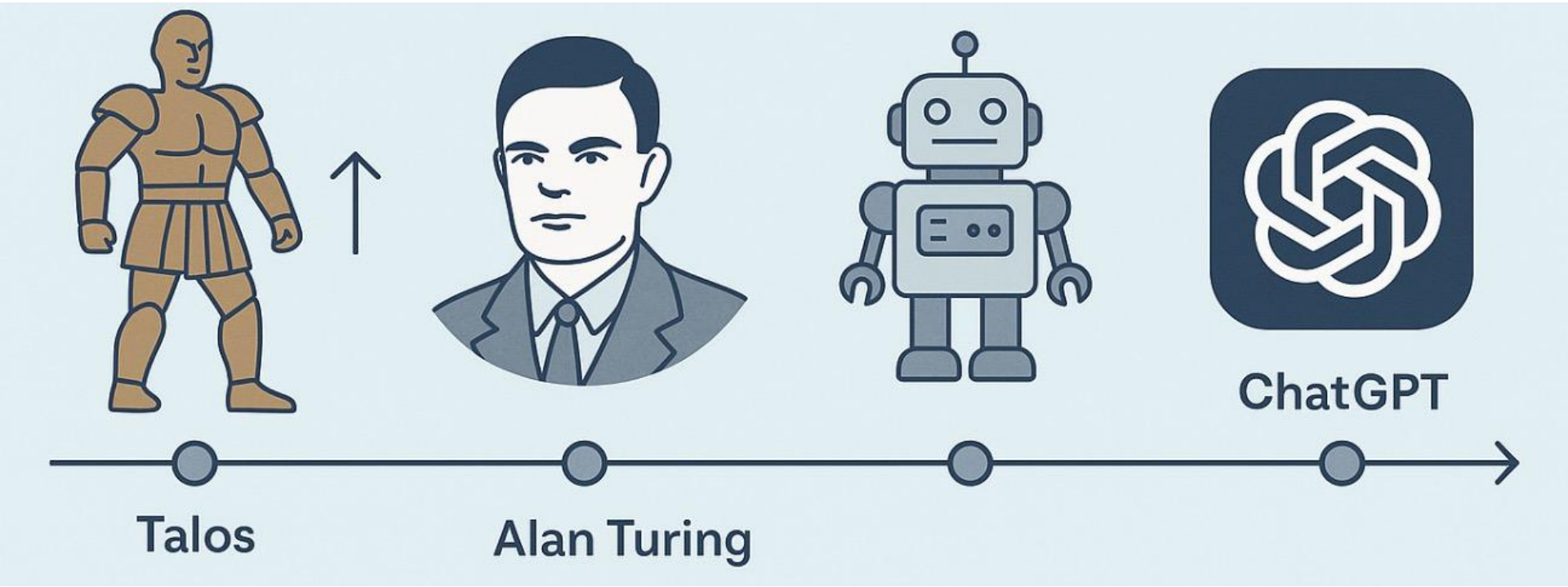
What is supervised learning

- Supervised learning is a machine learning paradigm where a model is trained using labeled data—that is, each input is paired with a known output.
-  It means that you will learn under the teacher's guidance
- The supervised learning will be with instructions, labeled examples, and teacher's feedback.

What is self-supervised learning?

- **Self-supervised learning:** A learning approach where patterns are discovered directly from the data itself, without needing outside labels or supervision—similar to figuring things out on your own by observing and connecting clues.
- You'll need to gather information independently, such as by exploring online resources and exchanging ideas with classmates.
- Throughout this self-directed learning process, you'll begin to form your own understanding and insights.

AI: From ancient dreams to modern reality



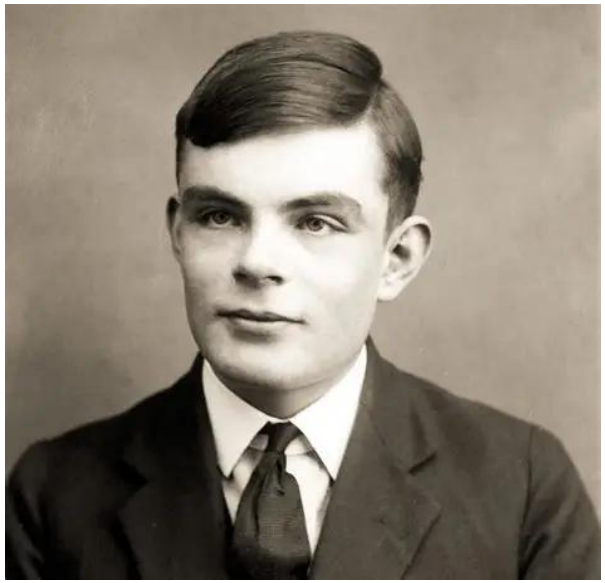
Before Computers — Ancient Myths

- **Talos,** an automaton of bronze who protected Cret （克里特岛） from pirates and invaders.

The Death of Talos

1950s — The Birth of AI

- AI becomes a science.



23 June 1912 – 7 June 1954

Alan Turing, an English mathematician, computer scientist, logician, cryptanalyst, philosopher and theoretical biologist.

What Is the Turing Test?

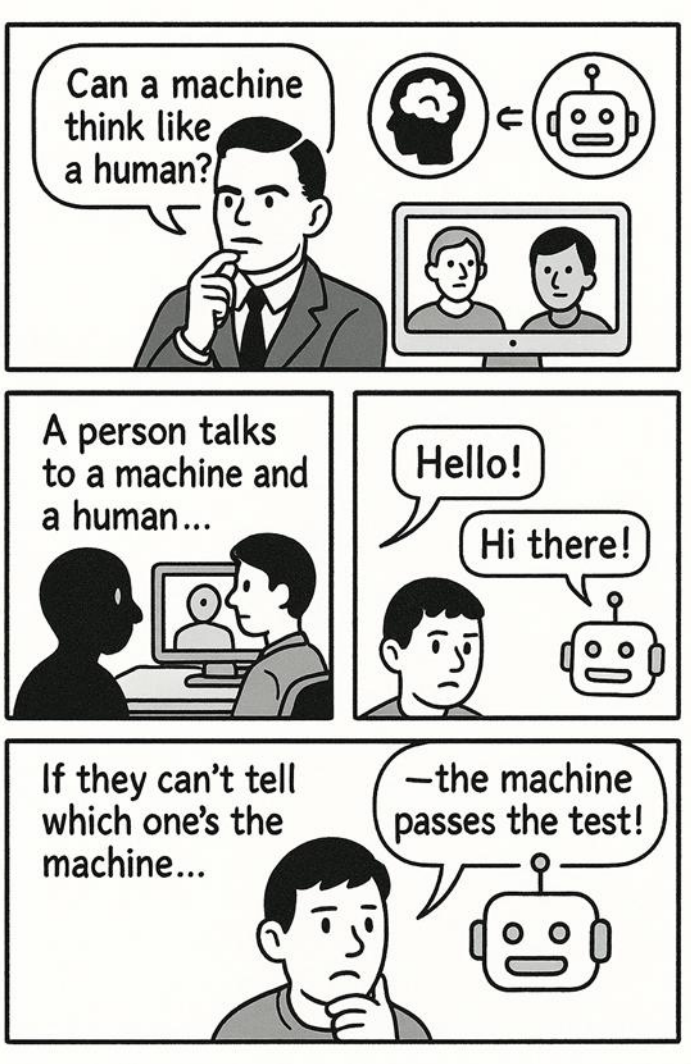
- Can a Machine Think Like a Human?
- Proposed by **Alan Turing** in 1950
- He asked:
  - 👉 *"Can machines think?"*
- His idea:
  - ✅ If a machine can **talk like a human** and fool a person, then it's **intelligent**.

⇩

This is the famous **Turing Test**

How the Turing Test Works

- A human talks (via text) to **two hidden entities**:
  - 👤 One human
  - 🤖 One machine
- If the tester **can't tell which is which**, the machine **passes the test**.
  - 💬 Machine needs to sound natural, smart, and human-like.
  - 📝 This test inspired **modern AI**, like chatbots and assistants!

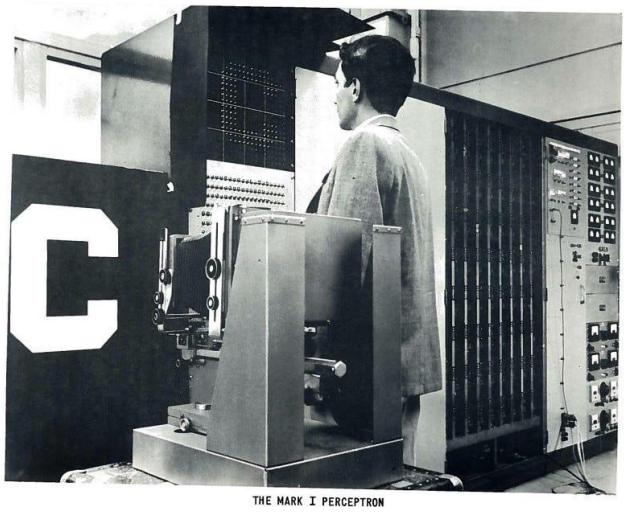


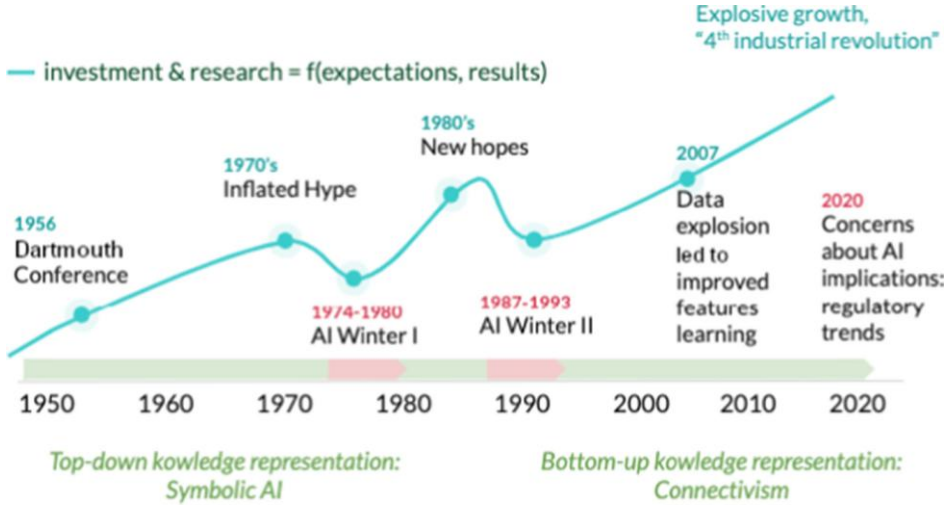
1956–1970 — Early Hopes

```
  Welcome to
                 EEEEEE  LL      IIII   ZZZZZZ   AAAAA
                 EE      LL       II       ZZ   AA   AA
                 EEEEE   LL       II     ZZZ    AAAAAAA
                 EE      LL       II    ZZ      AA   AA
                 EEEEEE  LLLLLL  IIII ZZZZZZ    AA   AA

  Eliza is a mock Rogerian psychotherapist.
  The original program was described by Joseph Weizenbaum in 1966.
  This implementation by Norbert Landsteiner 2005.


ELIZA: Is something troubling you ?
YOU:   Men are all alike.
ELIZA: What is the connection, do you suppose ?
YOU:   They're always bugging us about something or other.
ELIZA: Can you think of a specific example ?
YOU:   Well, my boyfriend made me come here.
ELIZA: Is it important to you that your boyfriend made you come here ?
YOU:   He says I'm depressed much of the time.
ELIZA: I am sorry to hear that you are depressed.
YOU:   It's true. I am unhappy.
ELIZA: Can you explain what made you unhappy ?
YOU:
```

The AI Winter Blues (1969)

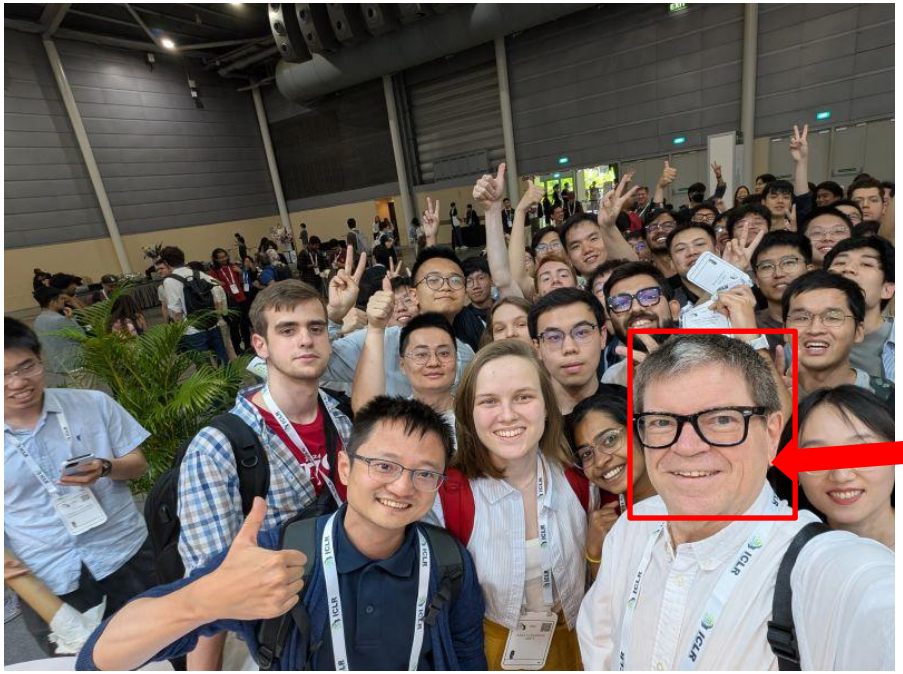
- Overpromises *v.s.* Actual capability, Funding cuts, lack of computing power.


THE MARK I PERCEPTRON



1990s: Handwriting Heroes

- **Yann LeCun's LeNet (1989)**:
  - Early CNN reading handwritten digits for checks.



Yann LeCun (楊立昆), a French-American computer scientist

A picture taken in ICLR 2025 held in Singapore

2000s: Deep Learning Jams

- **2006: Geoffrey Hinton**:
  - Deep Belief Networks learn without a teacher.

Wikipedia

Geoffrey Hinton

British-Canadian computer scientist

2024 Nobel Prize in Physics

Hinton's Family Tree

- 📐 Grandfather: George Boole, creator of Boolean logic — the foundation of modern computing

George Boole (2 November 1815 – 8 December 1864), an English mathematician and philosopher.

Operator	Notation	Alternative notations	Definition
AND	$x \wedge y$	x AND y, Kxy	$x \wedge y = 1$ if $x = y = 1$, $x \wedge y = 0$ otherwise
OR	$x \vee y$	x OR y, Axy	$x \vee y = 0$ if $x = y = 0$, $x \vee y = 1$ otherwise
NOT	$\neg x$	NOT x, Nx, $\overline{x}$, x', !x	$\neg x = 0$ if $x = 1$, $\neg x = 1$ if $x = 0$

Boolean logic

2010s: Deep Learning Boom

Fei-Fei Li (李飞飞), a Chinese-American computer scientist

GPUs Turn Up the Heat

- **2010s: NVIDIA GPUs**:
  - Made NN training crazy fast (weeks to hours!).

From Reddit

Jensen in **HK,** 24 Nov 2024

Jensen Huang, 黃仁勳

A Taiwanese-American businessman

President and CEO of Nvidia

2020s: Generative AI

- Closed-source LLM



Gemini ...

- Open-source LLM





...


A bunny reading his e-mail on a computer.


A crocodile fishing on a boat while reading a paper.


A bear astronaut playing tennis.


A green cow eating red grass during winter.


A Bichon Maltese and a black bunny playing backgammon.


Two people playing chess on Mars.

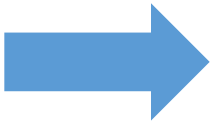
AI in 22nd century

How many AI components you can find in this figure?

Let's examine the AI components together.

Low-Altitude Intelligence

- Low-Altitude Intelligence refers to AI systems operating in **urban low-altitude environments** (typically <150 meters)



Natural Language Processing

- NLP is a branch of Artificial Intelligence that enables machines to understand, interpret, and generate human language.
  - 💬 Chatbots & Voice Assistants (e.g., Siri, ChatGPT)
  - 🌐 Language Translation (e.g., Google Translate)
  - 🧠 Sentiment Analysis (e.g., positive/negative reviews)

Doraemon can interpret and generate human languages

Embodied AI

- Embodied AI refers to AI systems integrated into physical bodies (robots, drones, autonomous agents) that perceive, move, and interact with the real world.

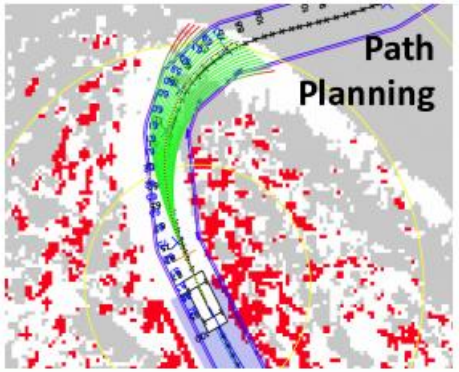
Current embodied AI

Future embodied AI

Doraemon has an AI system in his physical body

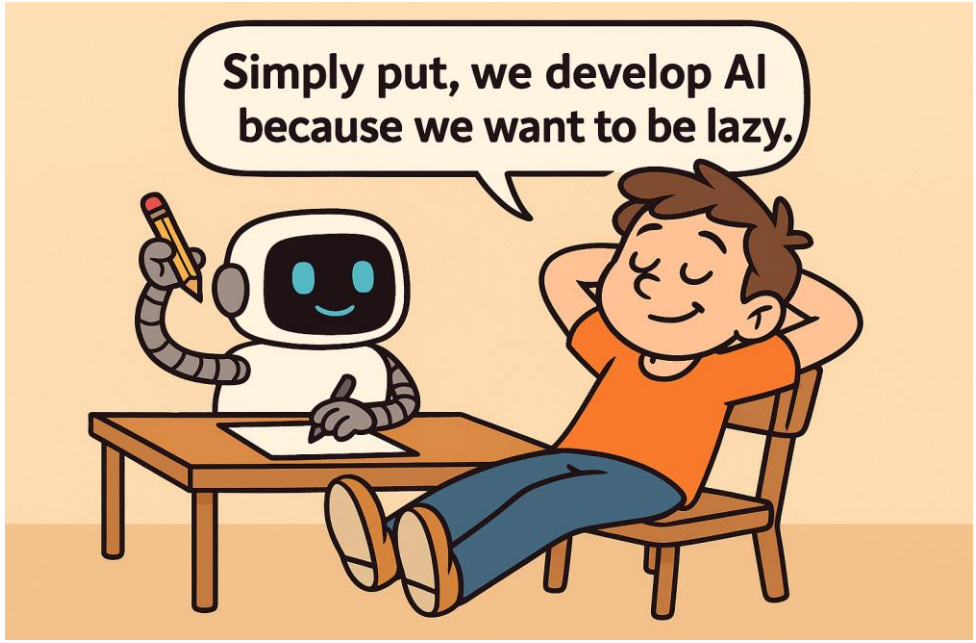
AI in our lives

Autonomous car technology



Why do we need AI?

- The purpose of AI is to fulfill our desire to accomplish tasks with minimal effort.
- Simply put, we develop AI because we want to be lazy.



Let us first see what human intelligence is.

Human intelligence

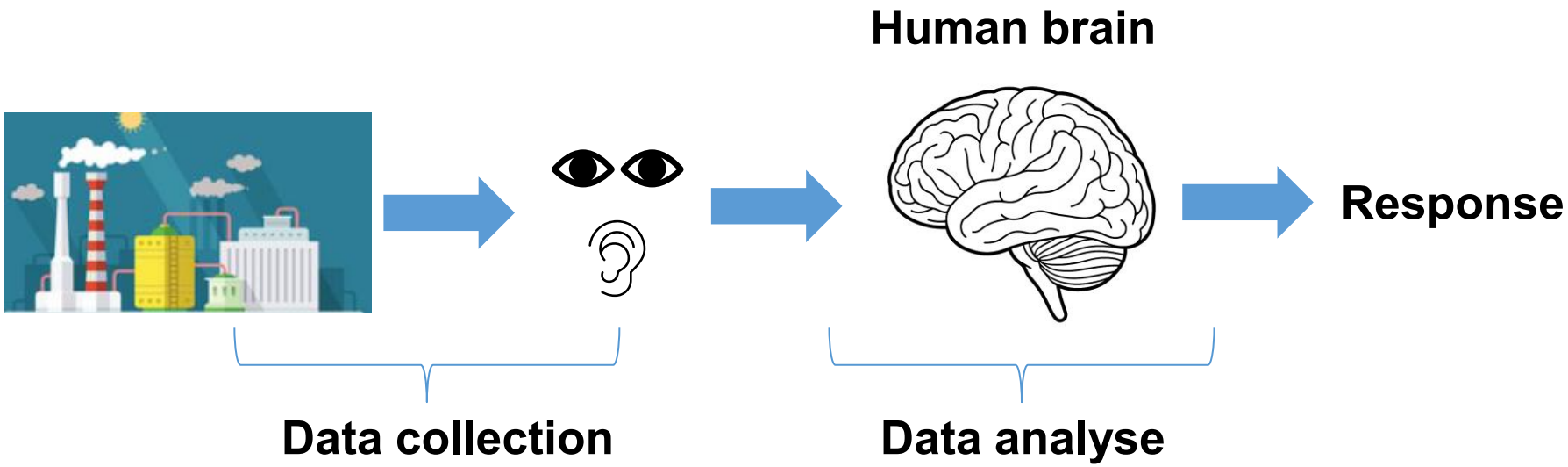
- AI is difficult. However, we can learn its core principles from the operations of human intelligence.
- The ability of Human Intelligence.
  - Ability to **learn** from experiences.
  - Ability to **adapt** to new situations.
  - Ability to **reason** and **make decisions**.
  - Ability to **create** and solve problems.

Human intelligence *vs.* AI

- Both **process information** and **learn patterns**.
- Human brain uses **neurons**; AI uses **artificial neurons**.
- Both improve with **training**.
- Key difference: AI learns from **data**, humans learn from **life experiences**.

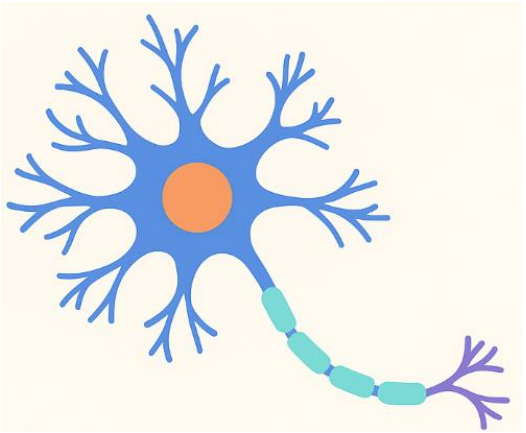
Human intelligence

- Human intelligence allows us to **perceive the world**, **analyze information**, and **respond appropriately**.
  - We collect data through senses like sight and hearing,
  - Our brain processes and interprets this information,
  - Then we make decisions or take actions based on that understanding.



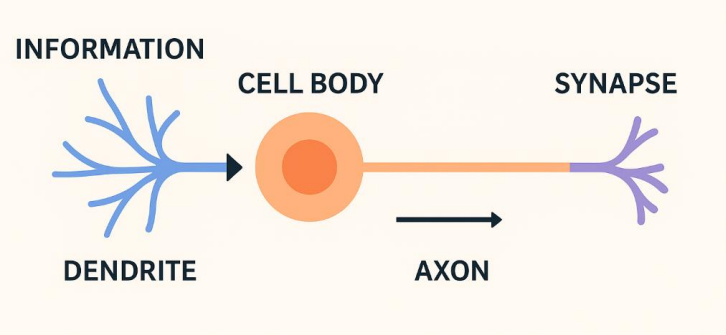
Brain = A Network of Neurons

- Our brain has billions of neurons
- Neurons send electric signals to each other
- These signals form thoughts, memories, and actions



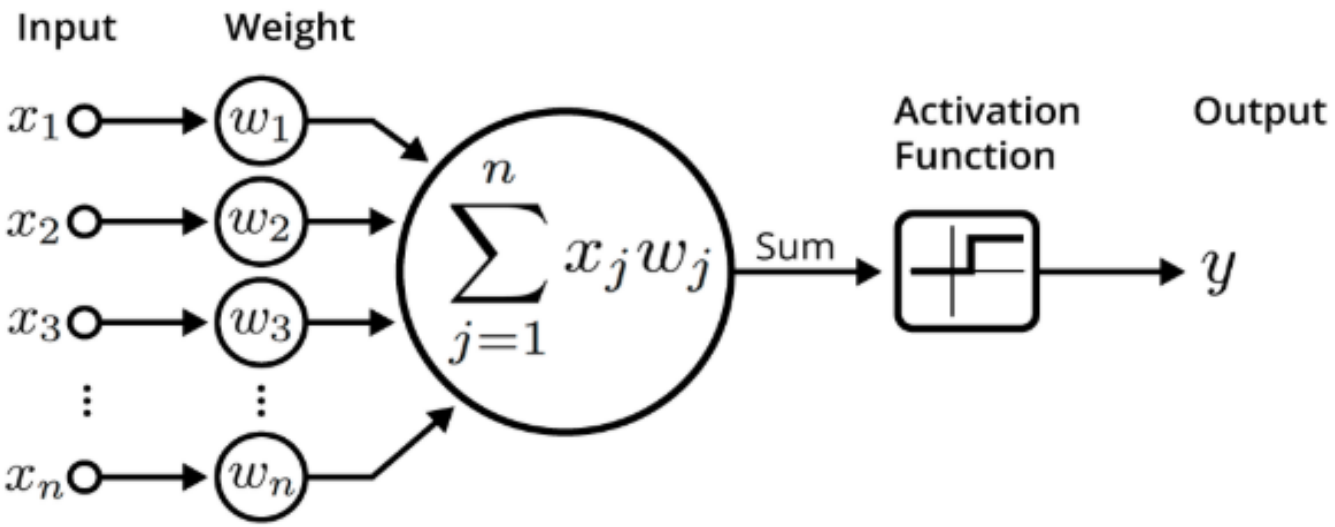
What a Biological Neuron Does

- **Receives signals** from many other neurons (inputs)
  - Dendrites (树突) collect electrical impulses from many connected neurons.
  - Each signal has different strengths (can be strong or weak).
- **Combines** them based on their strength (weighted sum)
  - The cell body adds up all signals.
  - Some signals are excitatory, others are inhibitory.
- **Fires** if the total signal exceeds a certain threshold
  - If the total input exceeds a certain threshold, the neuron fires (sends a spike).
  - If not, it remains inactive.



🧠 What is a Neuron in AI?

- A neuron is a tiny unit that processes information.
  - It takes inputs,
  - Processes them using weights and bias,
  - Then sends out an output.



🔍 This is the **simplest form of a neuron**, often called a *perceptron*.

From Neurons to Intelligence

- A single neuron processes basic signals, like a small decision-maker.
- When millions of neurons are interconnected, they can transmit, combine, and refine signals.
- These networks of neurons enable humans to perceive, learn, reason, and adapt.
- Complex intelligence emerges from the interactions between neurons, not just individual ones.

How Do Humans Learn?

- Through **experience** and **practice**.
- By **training and testing**.
- **Training and testing** include **feedback** to improve the understanding.

What is training and testing?

📘 **Training is like studying before the exam**

- The student (model) reads books and practices past papers
- The goal is to learn patterns and rules

📝 **Testing = Taking the Exam**

- Testing is like taking the actual exam
- The student (model) sees new questions they haven't seen before
- They must apply what they learned

Training: The student practices with homework and sample questions.

Testing: The student takes a final exam with **new questions**.

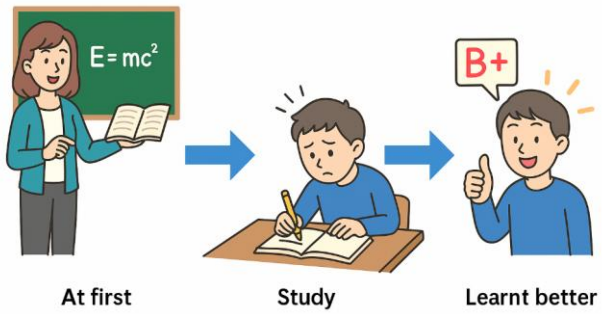
Rules during training and testing

- If the student sees the exam questions during practice, it's not a fair test.
- ❗ If the exam contains the **same questions** as the homework, it doesn't prove real learning — just memorization.

To fairly evaluate an AI model, it must be tested on data it hasn't seen during training.

How to train human intelligence?

- 🎓 **What Is a Student's Level at the Beginning of a class?**
  - At the very start, the student has no real understanding of the subject.
  - Their answers are mostly based on random guesses or intuition, not actual knowledge.
  - So, they may score very low
- 🎯 **What Happens After Training?**
  - After training, the student no longer guesses — they now understand the concepts.
  - They can answer questions confidently and correctly, even new ones they haven't seen before.
  - Their scores are consistently high, and they've developed real knowledge — not just memorization.



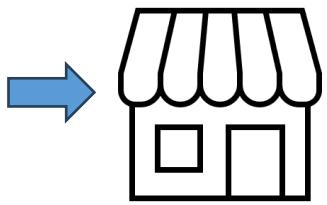
Human Learning for dough making

Dough making is the process of mixing flour with water to form a thick, pliable mixture that can be shaped into bread or other baked goods.

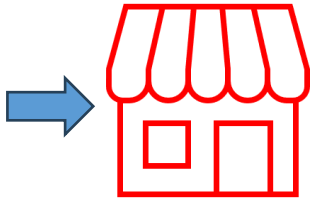
How to train human intelligence?

Alice buys flour to learn dough-making.

Alice

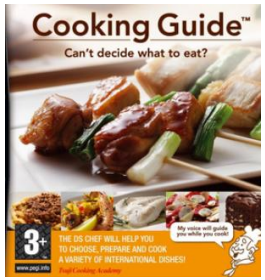


Flour



Dough

Dough-making is under the guidance of Cooking guide

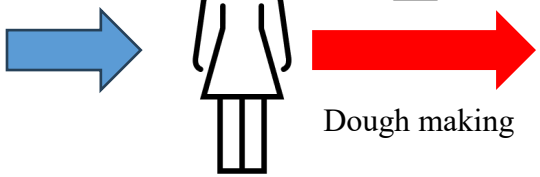


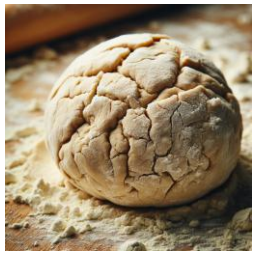
References provided by the cooking guide

How to train human intelligence?

First time:

Alice knows nothing about dough-making, and can only produce bad dough.





First Dough

References

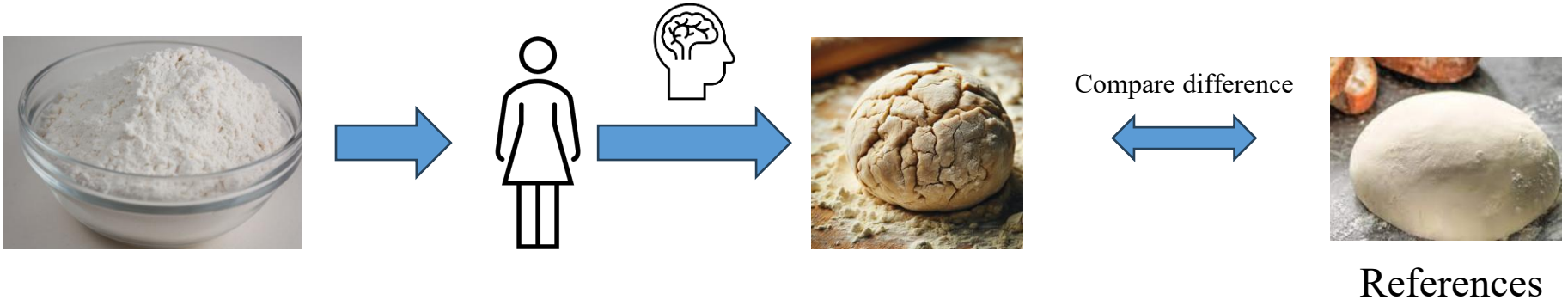
Bad quality, and very different from the references

How to train human intelligence?

First time:

Alice knows nothing about dough-making, and can only produce bad dough.

Alice compares the differences between the dough she made and the references.



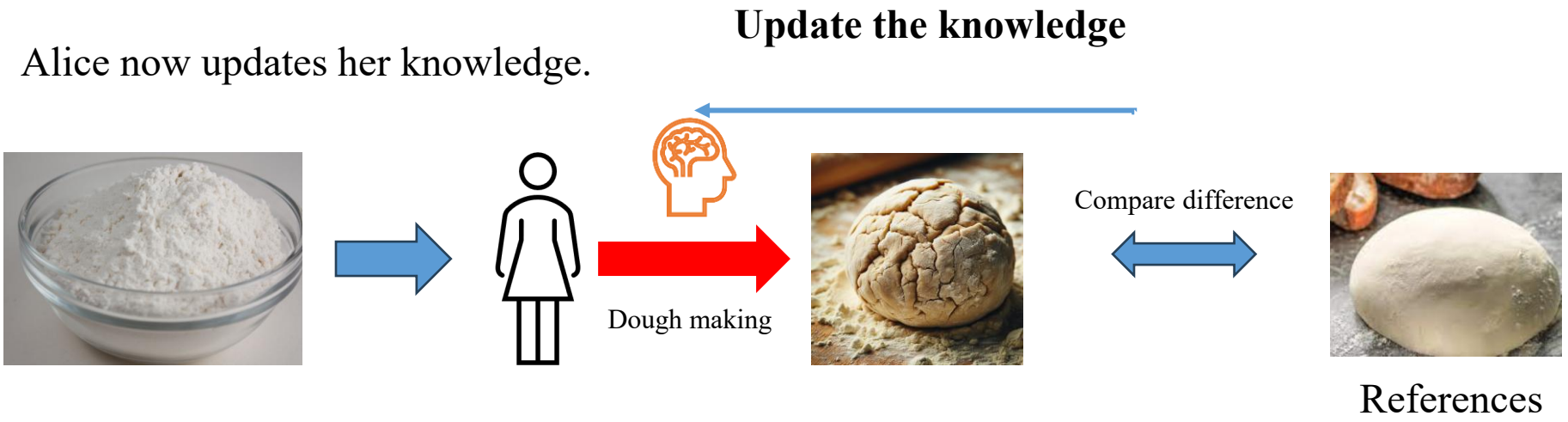
Bad quality, and very different from the references

Alice finds that **more water is needed**.

How to train human intelligence?

First time:

Alice now updates her knowledge.

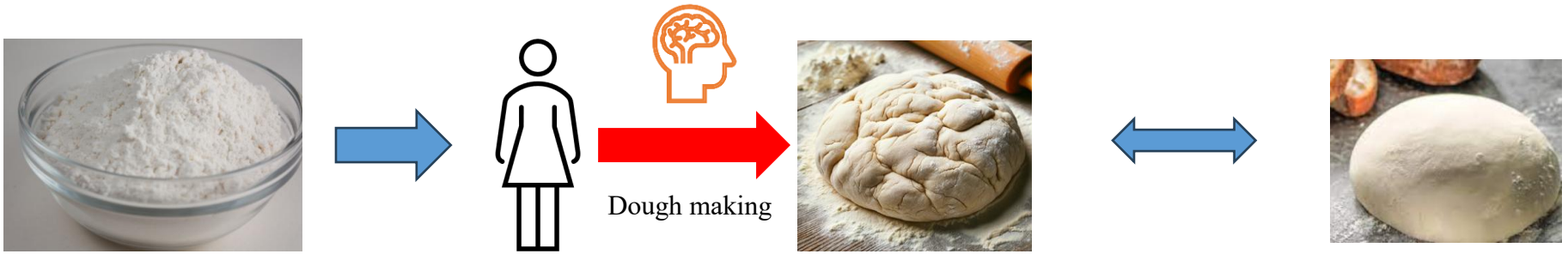


Bad quality, and very different from the references

Alice finds that **more water is needed**.

How to train human intelligence?

Second time:
With more water, Alice now can produce better dough

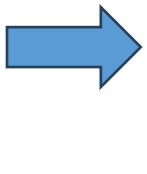


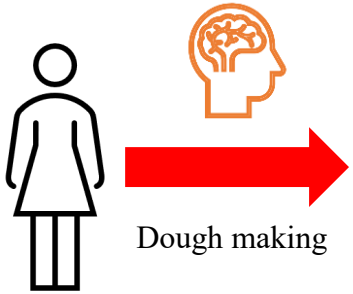
References

Better dough the second time, but still not as good as the references

How to train human intelligence?

Second time:
Compare the differences, find how to improve the dough quality.





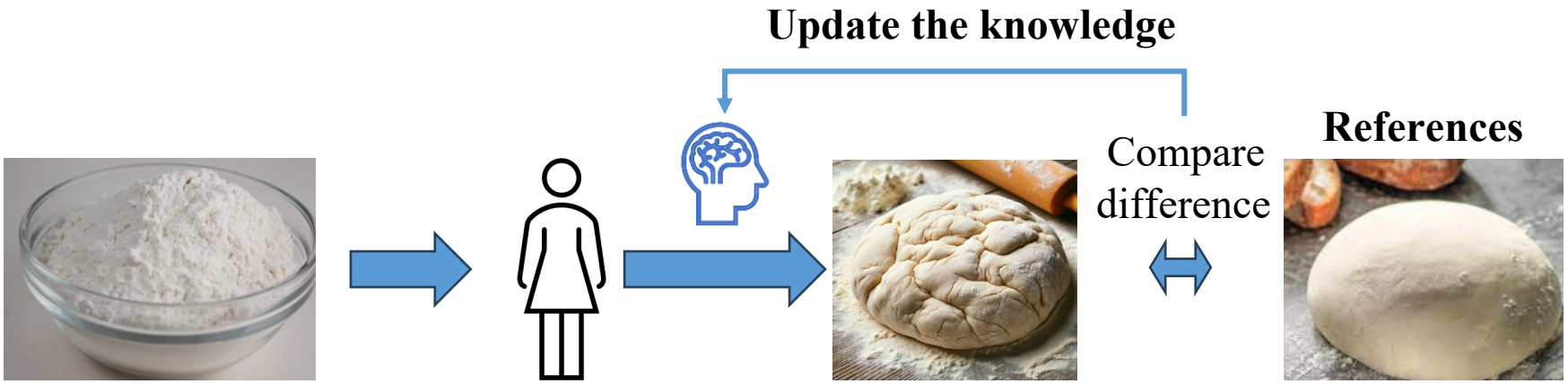
Compare difference

References

Better dough the second time, but still not as good as the references

How to train human intelligence?

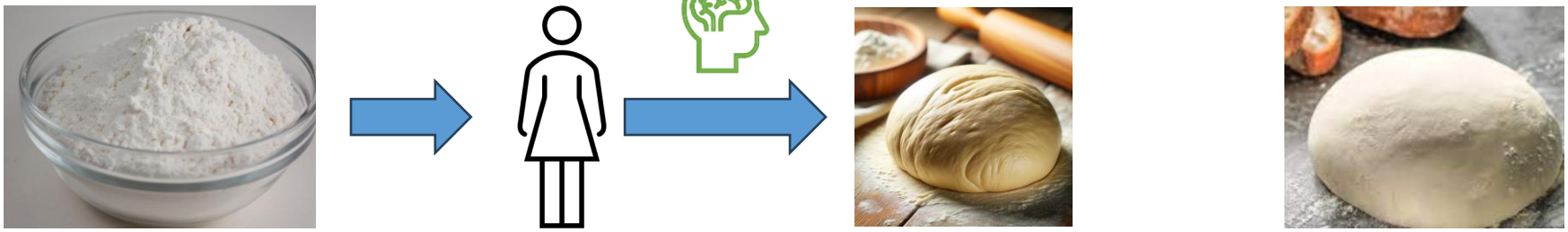
Second time: Update the knowledge



Better dough the second time, but still not as good as the references

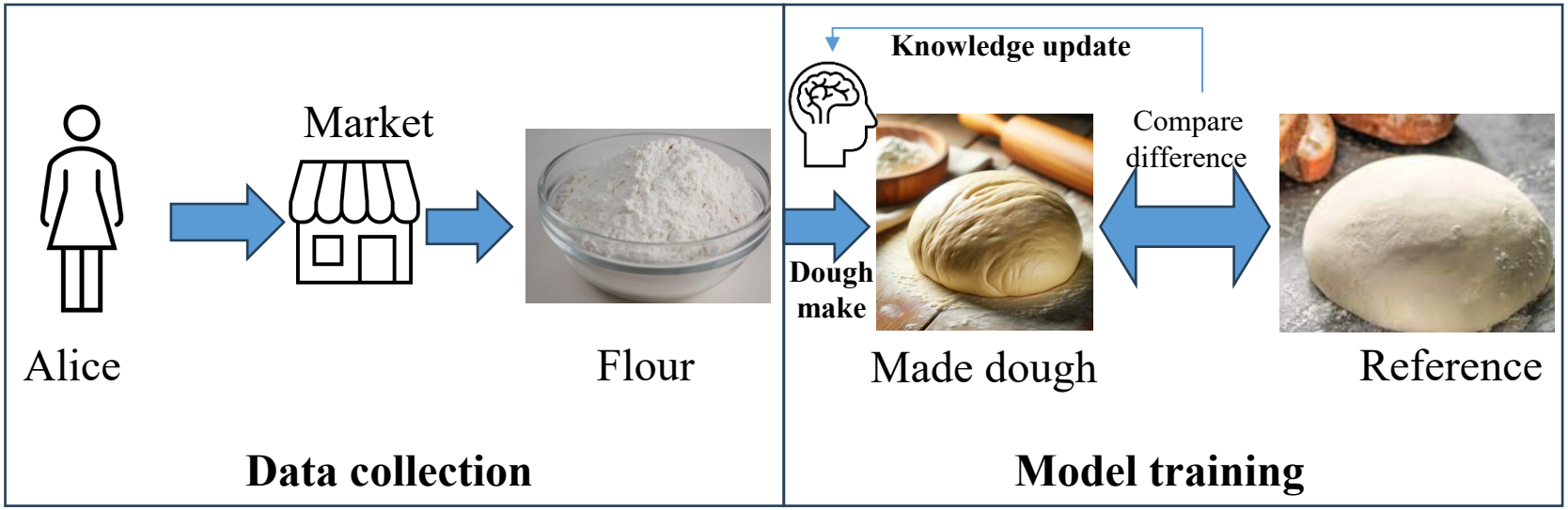
How to train human intelligence?

After several time



The final result obtained

Achieve best quality



- **Market**: Source of new experiences or materials.
- **Flour**: Raw material or information you learn from.
- **Dough make**: Apply what you know to create something.
- **Compare difference**: Check results against a standard.
- **Knowledge update**: Adjust skills or understanding based on feedback.

Correlations to AI

- **Market → Data source**
  - Human: A place where you get new experiences or materials.
  - AI: The dataset repository or data source where the model retrieves raw training data.
- **Flour → Input data**
  - Human: The raw material or knowledge you start with.
  - AI: The training samples fed into the model.
- **Dough make → Forward pass**
  - Human: Applying your current skills to create something.
  - AI: The model processes the input through its layers to produce an output (prediction).

Correlations to AI

- **Compare difference → Loss calculation**
  - Human: Checking the result against a standard or example.
  - AI: Comparing the model's prediction with the ground truth using a loss function.
- **Knowledge update → Backward**
  - Human: Adjusting what you know based on feedback.
  - AI: Updating the model's parameters via **backpropagation** to improve performance.

What is Forward?

- Forward (or forward pass) is the step where the neural network takes input data and produces an output (a prediction).
- **Process:**
  - Input data flows through the layers of the network.
  - Each layer applies weights and operations.
  - The final layer gives the prediction.
- **Analogy:**
  - Like a student solving a problem step by step to get an answer — before knowing whether it's right or wrong.

What is Backpropagation?

- Backpropagation is a method that tells a neural network **where it went wrong** and sends this error backward to fix the parameters.
- **Process**:
  - Make a prediction (forward pass).
  - Calculate the difference between prediction and the correct answer (loss).
  - Send this error backward through the layers.
  - Each layer updates its weights a little to do better next time.
- **Analogy:**
  - Like a student checking an exam, finding the wrong step, and correcting the exact mistake instead of only changing the final answer.

Process of AI training

- **Step-1**: Data Collection
  - Collect raw data from various sources
- **Step-2**: Input Preparation
  - Process and feed the raw data into the model
- **Step-3**: Forward Pass
  - Model processes the input through its layers to generate predictions
- **Step-4**: Loss Calculation
  - Compare predictions with ground truth to measure errors
- **Step-5**: Backward & Update
  - Use backpropagation to update model parameters and improve performance

The end