



## Machine Learning – Week 5.

In groups of 2-3.

*What is chain of thought? And how could that be useful?*

*Ask ChatGPT, and discuss in groups.*

Maybe, be inspired by conversations like below:

**Explain to me in simple terms what chain of thought is in the context of large language models.**

"Chain of thought" in the context of large language models refers to the model's ability to reason through a problem step by step, much like how a person thinks through a complex question. Instead of jumping straight to an answer, the model outlines the intermediate steps it takes to reach the solution.

**\*\*Imagine this scenario:\*\***

You're asked to solve the math problem, "What is 15 multiplied by 12?" Instead of instantly stating the answer, you might think:

1. 15 multiplied by 10 is 150.
2. 15 multiplied by 2 is 30.
3. Adding those together, 150 plus 30 equals 180.
4. Therefore, 15 multiplied by 12 is 180.

This step-by-step reasoning is your "chain of thought."

**\*\*In large language models:\*\***

When a language model uses a chain of thought, it generates responses that include these intermediate reasoning steps. This approach helps the model handle complex tasks that require understanding and reasoning, such as math problems, logic puzzles, or detailed explanations.

**\*\*Benefits of chain of thought:\*\***

- **\*\*Improved Accuracy:\*\*** By breaking down the problem, the model reduces the chance of errors that might occur if it tried to produce the answer in one step.
- **\*\*Transparency:\*\*** Users can follow the model's reasoning process, making it easier to trust and verify the answer.
- **\*\*Learning Aid:\*\*** It provides educational value by showing how to approach and solve similar problems.

**\*\*Summary:\*\***

The "chain of thought" is like the model thinking out loud. It doesn't just tell you the answer; it shows you how it got there. This makes the model's responses more understandable and reliable, especially for complex questions.

***Can you give an example of chain of thought that solves a puzzle that couldn't be solved without chain of thought?***

Certainly! Here's an example of a puzzle that requires a chain of thought to solve—something that a large language model would struggle to answer correctly without step-by-step reasoning.

**Puzzle:**

*Three boxes are labeled incorrectly. One contains only apples, one contains only oranges, and one contains both apples and oranges. You are allowed to open only one box and take out one piece of fruit*

*without looking inside. By tasting the fruit, how can you determine the correct labeling of all three boxes?*

Certainly! Here's an example of a puzzle that requires a chain of thought to solve—something that a large language model would struggle to answer correctly without step-by-step reasoning.

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### **Solution Using Chain of Thought:**

1. **Understand the Situation:**

- There are three boxes, each mislabeled:
- Box A: Labeled "Apples"
- Box B: Labeled "Oranges"
- Box C: Labeled "Apples and Oranges"

2. **Key Insight:**

- Since all boxes are labeled incorrectly, the labels do not represent their actual contents.

3. **Choose a Box to Open:**

- Open the box labeled "Apples and Oranges" (Box C).

4. **Reasoning:**

- **Case 1:** If you pick an apple from Box C:
  - Since Box C is mislabeled, and it can't be "Apples and Oranges," and you drew an apple, it must contain only apples.
  - Now, the box labeled "Oranges" (Box B) cannot contain oranges (it's mislabeled), and it cannot contain apples (Box C contains all the apples). Therefore, Box B must contain both apples and oranges.

- The remaining box labeled "Apples" (Box A) must contain oranges.
- **Case 2:** If you pick an orange from Box C:
  - Similar logic applies. Box C must contain only oranges.
  - The box labeled "Apples" (Box A) cannot contain apples, and it cannot contain oranges (Box C has all the oranges). Therefore, Box A must contain both fruits.
  - The remaining box labeled "Oranges" (Box B) must contain apples.

#### 5. **Finalize the Solution:**

- **If you drew an apple from Box C:**
  - Box C: **Apples**
  - Box labeled "Oranges" (Box B): **Apples and Oranges**
  - Box labeled "Apples" (Box A): **Oranges**
- **If you drew an orange from Box C:**
  - Box C: **Oranges**
  - Box labeled "Apples" (Box A): **Apples and Oranges**
  - Box labeled "Oranges" (Box B): **Apples**

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#### **Answer:**

- **If you pick an apple from the box labeled "Apples and Oranges":**
  - **Box labeled "Apples and Oranges"** contains **Apples**.
  - **Box labeled "Oranges"** contains **Apples and Oranges**.
  - **Box labeled "Apples"** contains **Oranges**.

- **\*\*If you pick an orange from the box labeled "Apples and Oranges":\*\***

- **\*\*Box labeled "Apples and Oranges" contains \*\*Oranges\*\*.**

- **\*\*Box labeled "Apples" contains \*\*Apples and Oranges\*\*.**

- **\*\*Box labeled "Oranges" contains \*\*Apples\*\*.**

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**### \*\*Explanation:\*\***

Without step-by-step reasoning, it's challenging to keep track of the mislabeling and deduce the correct contents of each box based on a single piece of fruit. The chain of thought allows the model (or a person) to systematically eliminate possibilities and logically arrive at the correct labeling.

**\*\*Why This Requires Chain of Thought:\*\***

- **\*\*Complex Deduction:\*\*** The puzzle involves understanding that all labels are incorrect and using that information to deduce the actual contents.

- **\*\*Elimination Process:\*\*** You have to consider multiple scenarios and eliminate impossibilities.

- **\*\*Logical Sequencing:\*\*** Each step depends on the previous one, requiring a coherent thought process.

**\*\*Without Chain of Thought:\*\***

- A model might incorrectly assume the contents based on the fruit drawn without properly accounting for the mislabeling.

- It may jump to conclusions without considering all necessary logical steps.

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**\*\*Summary:\*\***

This puzzle demonstrates how chain of thought enables the solver to navigate complex logical relationships step by step. It showcases the importance of intermediate reasoning steps in reaching a correct solution that would be difficult to obtain through a direct answer.

### **How is chain of thought used in the o1 preview model?**

Chain of Thought (CoT) in the context of the **o1 preview model** is a crucial feature that enhances the model's reasoning capabilities. Here's how it's utilized:

#### **1. Internal Step-by-Step Reasoning:**

- The o1 preview model employs an internal chain of thought process where it breaks down complex questions into smaller, manageable steps.
- This internal reasoning allows the model to consider each component of a problem sequentially before arriving at a final answer.

#### **2. Improved Accuracy and Consistency:**

- By reasoning through problems step by step, the model reduces the likelihood of errors that might occur if it tried to provide an answer in one leap.
- This leads to more accurate and consistent responses, especially for complex tasks like mathematical calculations, logical reasoning, and multi-part questions.

#### **3. Hidden Chain of Thought:**

- Unlike previous models that might display their reasoning process in the output, the o1 preview model often keeps the chain of thought **hidden** from the user.
- This means the model provides a concise answer without necessarily showing all the intermediate steps, resulting in a cleaner and more straightforward response.

#### **4. User-Controlled Transparency:**

- If a user wants to see the step-by-step reasoning, they can request it explicitly by asking for a detailed explanation or a step-by-step solution.
- This flexibility allows users to access the chain of thought when needed without it being always present.

#### **5. Enhanced Problem-Solving Abilities:**

- The chain of thought mechanism enables the model to handle more complex queries that require multi-step reasoning.

- It can solve puzzles, perform elaborate calculations, and provide detailed explanations when prompted.

#### 6. **Training with Chain of Thought Data:**

- The o1 preview model has been trained on datasets that include examples of chain of thought reasoning.

- This training helps the model learn how to process and generate logical sequences internally, improving its overall performance.

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#### **Example:**

- **User Question:** "If a car travels at 60 miles per hour for 2.5 hours, how far does it travel?"

- **Model's Internal Chain of Thought:**

1. Recognize the formula:  $\text{Distance} = \text{Speed} \times \text{Time}$ .
2. Calculate:  $60 \text{ miles/hour} \times 2.5 \text{ hours} = 150 \text{ miles}$ .

- **Model's Response:** "The car travels 150 miles."

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#### **Summary:**

In the o1 preview model, the chain of thought is used as an internal tool to enhance reasoning without necessarily displaying all the intermediate steps to the user. This approach provides:

- **Efficiency:** Quick and direct answers for straightforward queries.

- **Depth on Demand:** Detailed explanations available when the user requests them.

- **Improved Accuracy:** Reduced errors through internal step-by-step reasoning.
- **Better User Experience:** Cleaner responses that are easier to read while still being reliable.

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#### **How to Access the Chain of Thought:**

- If you want to see the model's reasoning, you can prompt it by saying:
  - "Explain your reasoning."
  - "Show me the step-by-step solution."
  - "Provide a detailed explanation."

This tells the model that you're interested in its chain of thought, and it will include the intermediate steps in its response.