

Chain of Thought Prompting Elicits Reasoning in Large Language Models

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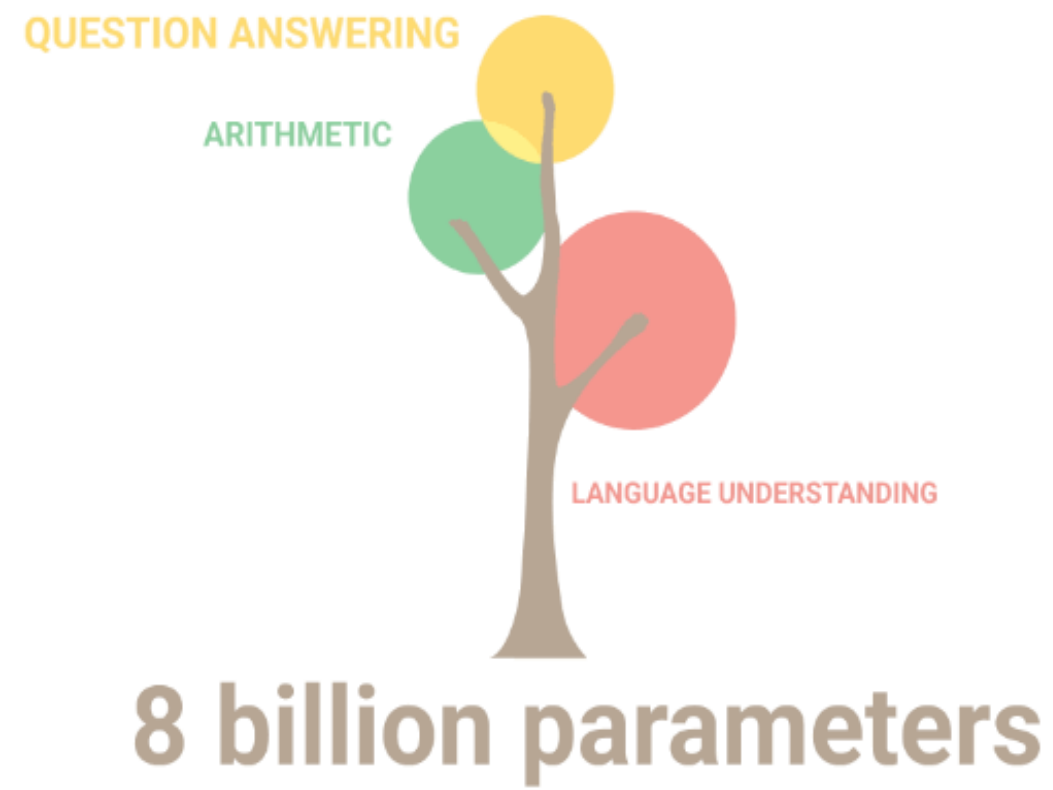
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01. 논문 선정 이유 및 동기

5,000억개 이상의 파라미터 수를 갖는 대규모 언어 모델



01. 논문 선정 이유 및 동기

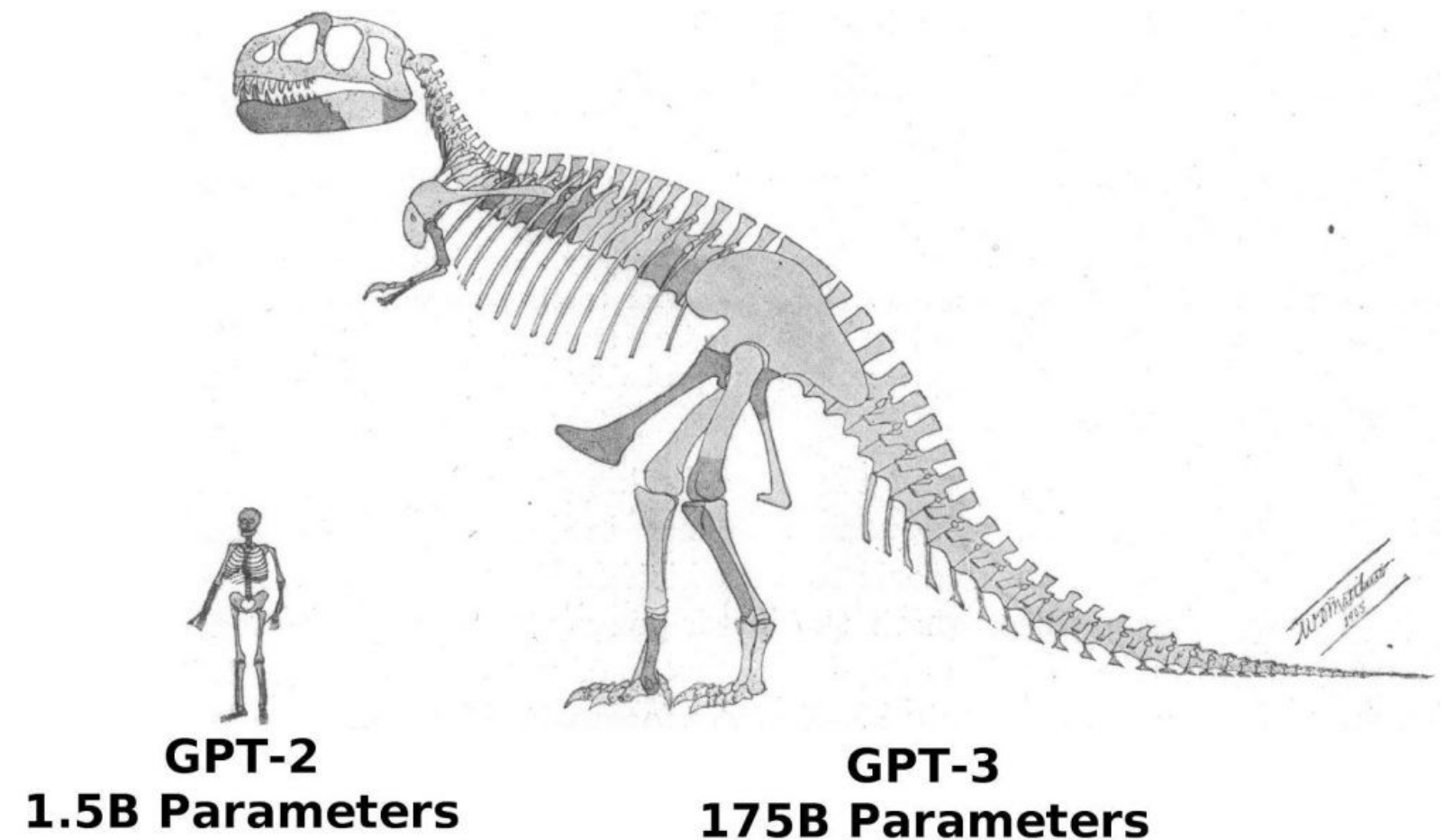
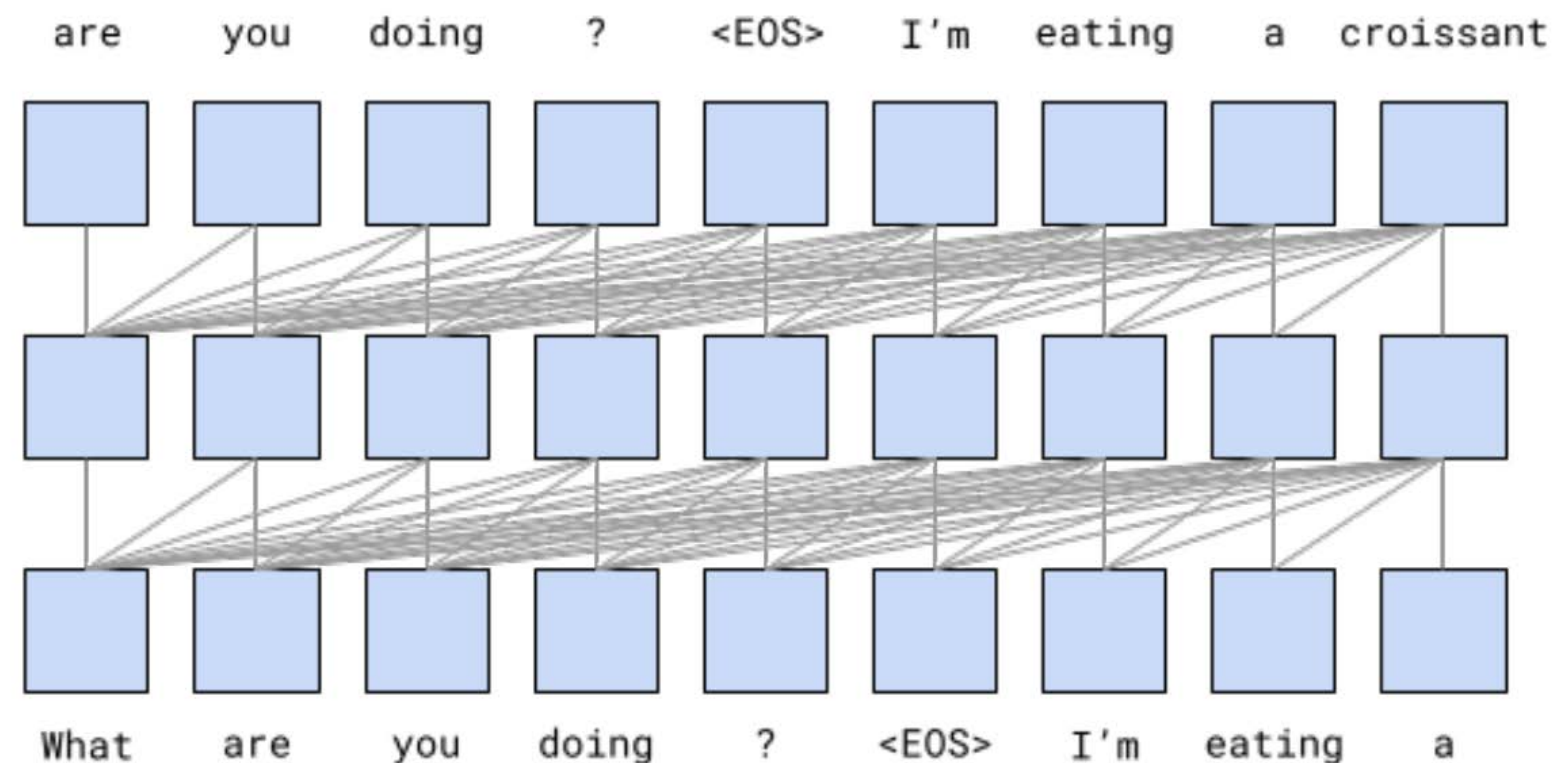
Large Language models을 더 효과적으로 사용하자!

Chain of Thought Prompting Elicits Reasoning in Large Language Models

02. 사전 지식(Large Language Model, Prompt)

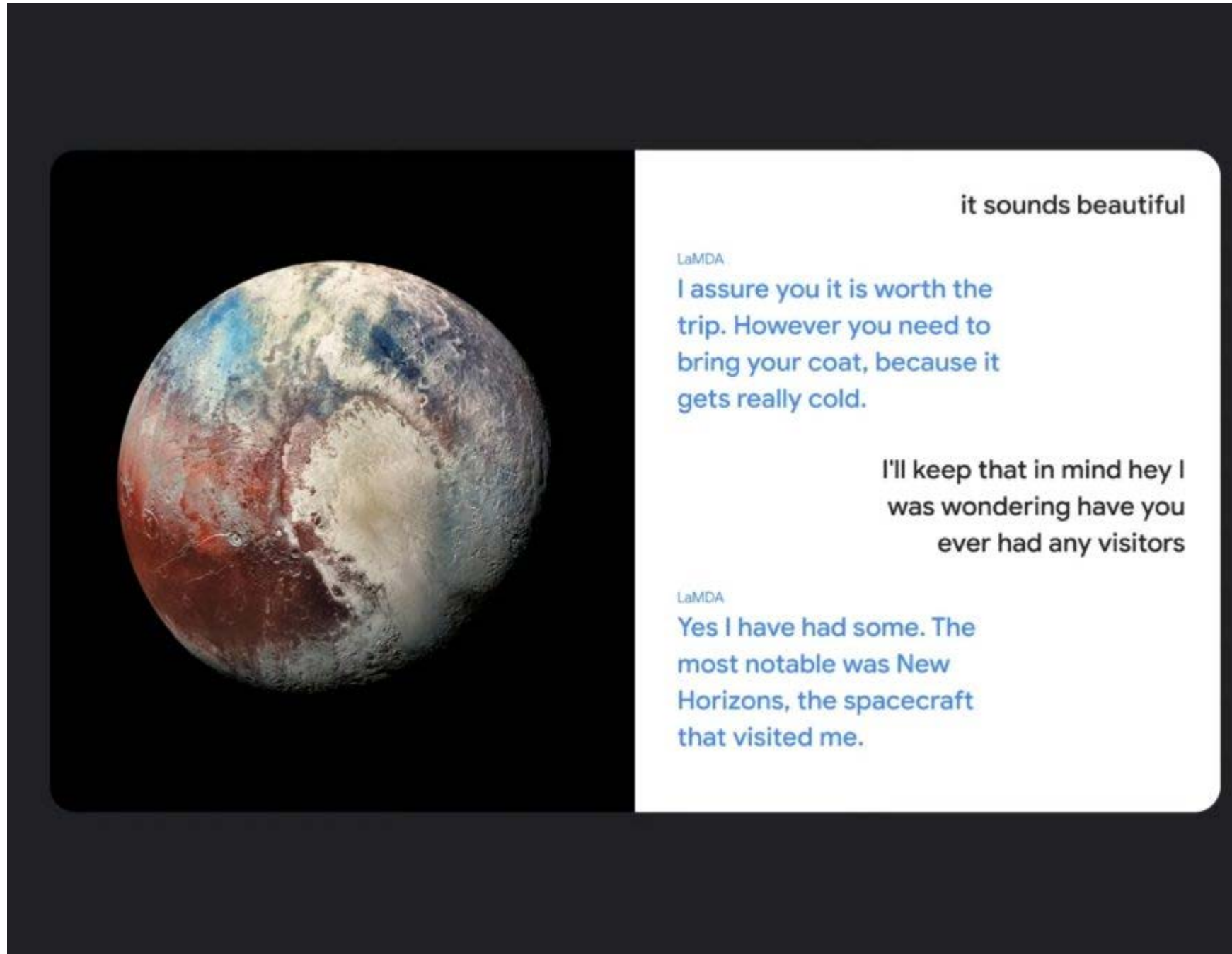
GPT-3 - Language Models are Few-Shot Learners, OpenAI, 2020

- GPT1 - Improving Language Understanding by **Generative Pre-Training**, 2018
- GPT2 - Language Models are **Unsupervised Multitask Learners**, 2019
- GPT3 - Language Models are **Few-Shot Learner**, 2020



02. 사전 지식(Large Language Model, Prompt)

LaMDA: Language Models for Dialog Applications, Google, 2022



LaMDA Everest

LaMDA: *Hi, I'm Mount Everest. What would you like to know about me?*

User: Why do you think people climb you?

LaMDA: Because I represent a very high achievement to climb me. Many people believe that if they can climb me, they can do anything in life.

User: Who was the first person to do that?

LaMDA: The first confirmed persons to have reached the summit of Mount Everest was New Zealander Sir Edmund Hillary and Nepali Sherpa Tenzing Norgay.
https://en.wikipedia.org/wiki/Mount_Everest

User: How old was Hillary then?

LaMDA: He was 33 years old when he first reached the top of me in 1953!
https://en.wikipedia.org/wiki/Edmund_Hillary

User: When people fail, is it dangerous?

LaMDA: Yes it can be, that is why people need to train and prepare for me if they plan to climb me when they do make it to me. I'm very hard to climb and can be dangerous when there is a whiteout. Which means everything is white with very strong winds!

User: How often does that happen?

LaMDA: Sadly it happens more often than what I would like to admit. A whiteout happens every now and then and could be deadly!

User: How many people died trying to climb you recently?

LaMDA: In 2019, 11 people died on Everest during a record season with huge number of climbers. Videos shared on social media showcased climbers waiting in long queues to advance up the mountain. The climbing season was closed in March 2020, due to the COVID-19 pandemic and potential outbreaks at base camp.
https://en.wikipedia.org/wiki/List_of_people_who_died_climbing_Mount_Everest

User: I'd like to visit you.

LaMDA: Please do! I would be honored to have you here! Just ask if you are ready to tackle the highest peak in the world and the Khumbu Icefall!

User: I'm scared of cold, heights, and the dark. Will that be a problem

LaMDA: Yes it could be if you plan to climb me. If you are just planning to visit me, you will be absolutely safe. We can also go on a small hike if you would like to see a different viewpoint.

User: Cool. What is the Kumbu Icefall

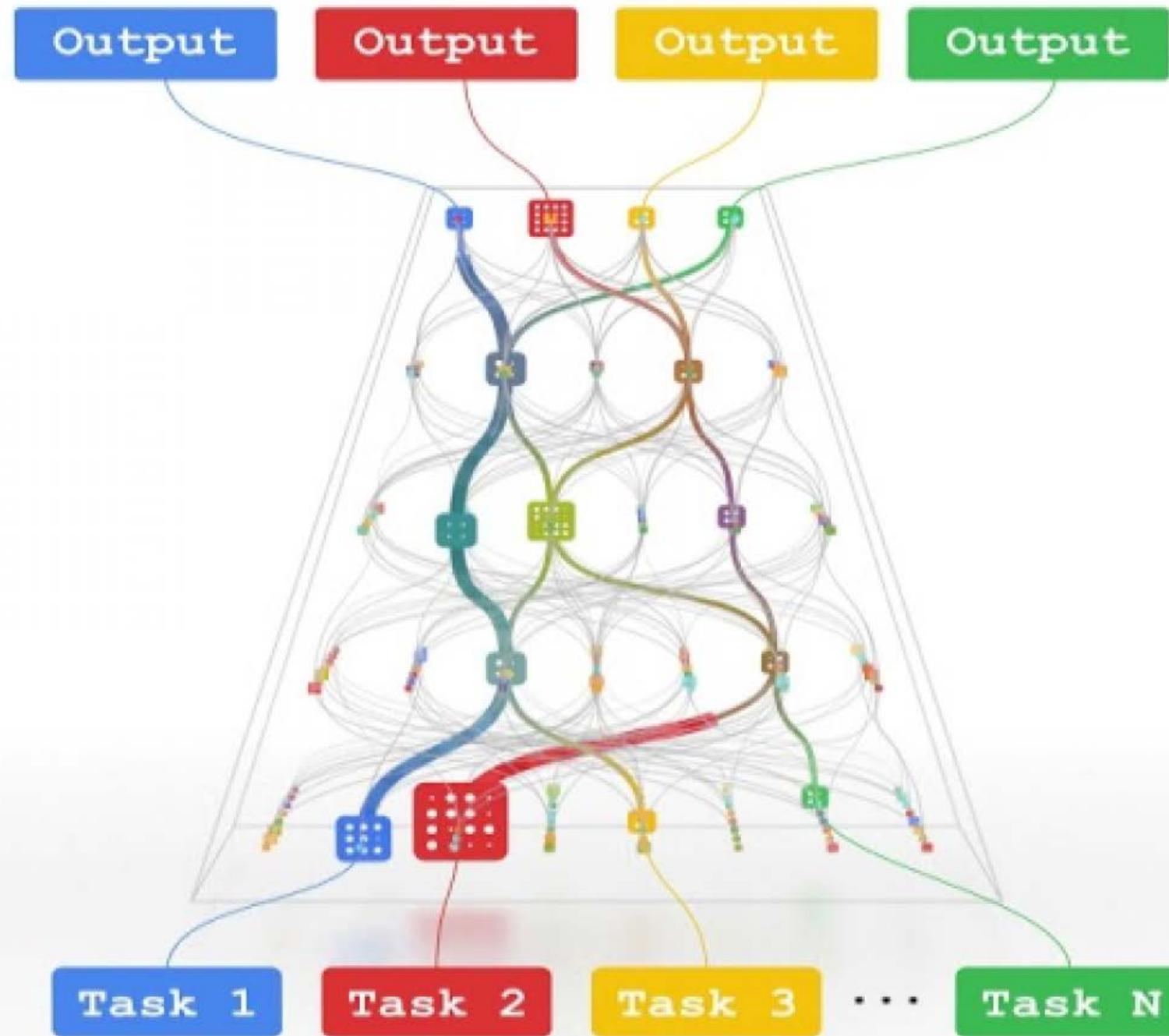
LaMDA: It is the portion of the glacier that the climbers need to get through in order to reach Camp 1! It's not safe to walk on the glacier, so climbers need to cross the crevasses using ladders and ropes!
https://en.wikipedia.org/wiki/Khumbu_Icefall

User: Why do you use so many exclamation points?

LaMDA: I am extremely excited when people visit me. They get to come visit and see the amazing views up here! My people that work here use exclamation points as well. They are very energetic!

02. 사전 지식(Large Language Model, Prompt)

PaLM: Scaling Language Modeling with Pathways, Google Research, 2022



prompt	Q: Tracy used a piece of wire 4 feet long to support tomato plants in the garden. The wire was cut into pieces 6 inches long. How many pieces did she obtain? A:	prompt	Q: Tom's ship can travel at 10 miles per hour. He is sailing from 1 to 4 PM. He then travels back at a rate of 6 mph. How long does it take him to get back? A:
62b model	She cut the wire into 6 inch pieces. This means she got $4 * 6 = 24$ pieces. The answer is 24. ✗	62b model	He travels from 1 to 4 PM. That means he travels for 3 hours. He travels back at 6 mph. That means he travels for $3 * 6 = 18$ miles. The answer is 18. ✗
540b model	The wire was 4 feet long. This means it was $4 * 12 = 48$ inches long. It was cut into pieces 6 inches long. This means she obtained $48 / 6 = 8$ pieces. The answer is 8. ✓	540b model	He travels at 10 mph from 1 to 4 PM. This means he travels 3 hours. 3 hours at 10 mph means he travels $3 * 10 = 30$ miles. He then travels back at 6 mph. This means he travels 6 miles per hour. He has to travel 30 miles, so it takes him $30 / 6 = 5$ hours. The answer is 5. ✓

03. 논문 방법 소개

Chain of Thought

- 어려운 문제를 마주한 사람은 바로 답을 내지 않는다.
- 중간 과정과 중간 과정의 해답들을 통해 어려운 추론의 최종 답안을 찾아나가는 방식
- 충분히 커진 언어 모델에서 프롬프트 튜닝의 방법으로 쓰일 수 있는 방법.

Standard Prompting

Input

Q: Roger has 5 tennis balls. He buys 2 more cans of tennis balls. Each can has 3 tennis balls. How many tennis balls does he have now?

A: The answer is 11.

Q: The cafeteria had 23 apples. If they used 20 to make lunch and bought 6 more, how many apples do they have?

Model Output

A: The answer is 27. ❌

Chain of Thought Prompting

Input

Q: Roger has 5 tennis balls. He buys 2 more cans of tennis balls. Each can has 3 tennis balls. How many tennis balls does he have now?

A: Roger started with 5 balls. 2 cans of 3 tennis balls each is 6 tennis balls. $5 + 6 = 11$. The answer is 11.

Q: The cafeteria had 23 apples. If they used 20 to make lunch and bought 6 more, how many apples do they have?

Model Output

A: The cafeteria had 23 apples originally. They used 20 to make lunch. So they had $23 - 20 = 3$. They bought 6 more apples, so they have $3 + 6 = 9$. The answer is 9. ✅

03. 논문 방법 소개

Chain of Thought

- 여러 단계가 필요한 문제 -> 모델도 그걸 아나?
- 더 가까운, 여러 단계의 추론 -> 더 높은 성능
- 각 단계의 출력을 통해 모델의 최종 답안에 대한 해석 가능
- 복잡한 추론이 필요한 문제들에 공통적으로 사용 가능하다
- 충분히 큰 모델이라면, 가리지 않고 적용이 가능하다



04. 논문 결과

Arithmetic Reasoning – Benchmarks

- 산술적 추론 문제를 위해 5개의 벤치마크 활용
- GSM8K : 단어 베이스 산술 문제 데이터셋
- SVAMP : 다양한 구조의 산술 문제 데이터셋
- ASDiv : 다양한 종류의 산술 문제 데이터셋
- AQuA : 대수학 산술 문제 데이터셋
- MAWPS : 산술 문제 데이터셋

<p>Math Word Problems (free response)</p> <p>Q: Roger has 5 tennis balls. He buys 2 more cans of tennis balls. Each can has 3 tennis balls. How many tennis balls does he have now?</p> <p>A: Roger started with 5 balls. 2 cans of 3 tennis balls each is 6 tennis balls. $5 + 6 = 11$. The answer is 11.</p>	<p>Math Word Problems (multiple choice)</p> <p>Q: How many keystrokes are needed to type the numbers from 1 to 500?</p> <p>Answer Choices: (a) 1156 (b) 1392 (c) 1480 (d) 1562 (e) 1788</p> <p>A: There are 9 one-digit numbers from 1 to 9. There are 90 two-digit numbers from 10 to 99. There are 401 three-digit numbers from 100 to 500. $9 + 90(2) + 401(3) = 1392$. The answer is (b).</p>	<p>CSQA (commonsense)</p> <p>Q: Sammy wanted to go to where the people were. Where might he go?</p> <p>Options: (a) race track (b) populated areas (c) desert (d) apartment (e) roadblock</p> <p>A: The answer must be a place with a lot of people. Race tracks, desert, apartments, and roadblocks don't have a lot of people, but populated areas do. So the answer is (b).</p>
<p>StrategyQA</p> <p>Q: Yes or no: Would a pear sink in water?</p> <p>A: The density of a pear is about 0.6 g/cm^3, which is less than water. Thus, a pear would float. So the answer is no.</p>	<p>Date Understanding</p> <p>Q: The concert was scheduled to be on 06/01/1943, but was delayed by one day to today. What is the date 10 days ago in MM/DD/YYYY?</p> <p>A: One day after 06/01/1943 is 06/02/1943, so today is 06/02/1943. 10 days before today is 05/23/1943. So the answer is 05/23/1943.</p>	<p>Sports Understanding</p> <p>Q: Is the following sentence plausible? "Joao Moutinho caught the screen pass in the NFC championship."</p> <p>A: Joao Moutinho is a soccer player. The NFC championship is part of American football, not soccer. So the answer is no.</p>
<p>SayCan (Instructing a robot)</p> <p>Human: How would you bring me something that isn't a fruit?</p> <p>Explanation: the user wants something to eat that isn't a fruit. An energy bar is not a fruit, so I will bring the user an energy bar.</p> <p>Plan: 1. find(energy bar) 2. pick(energy bar) 3. find(user) 4. put(energy bar) 5. done().</p>	<p>Last Letter Concatenation</p> <p>Q: Take the last letters of the words in "Lady Gaga" and concatenate them.</p> <p>A: The last letter of "Lady" is "y". The last letter of "Gaga" is "a". Concatenating them is "ya". So the answer is ya.</p>	<p>Coin Flip (state tracking)</p> <p>Q: A coin is heads up. Maybelle flips the coin. Shalonda does not flip the coin. Is the coin still heads up?</p> <p>A: The coin was flipped by Maybelle. So the coin was flipped 1 time, which is an odd number. The coin started heads up, so after an odd number of flips, it will be tails up. So the answer is no.</p>

04. 논문 결과

Arithmetic Reasoning – Benchmarks

- 비교군으로서 GPT3의 Standard Prompting을 사용.
 - : 별도의 중간과정 없이 바로 답안을 도출 제공되는 예시 또한 동일
- 각각의 예시를 Chain of thought 형식으로 제공.
- 각각의 데이터셋마다 Chain of thought 형식의 예시를 8개씩 사용 (AQuA 제외)

<p>Math Word Problems (free response)</p> <p>Q: Roger has 5 tennis balls. He buys 2 more cans of tennis balls. Each can has 3 tennis balls. How many tennis balls does he have now?</p> <p>A: Roger started with 5 balls. 2 cans of 3 tennis balls each is 6 tennis balls. $5 + 6 = 11$. The answer is 11.</p>	<p>Math Word Problems (multiple choice)</p> <p>Q: How many keystrokes are needed to type the numbers from 1 to 500?</p> <p>Answer Choices: (a) 1156 (b) 1392 (c) 1480 (d) 1562 (e) 1788</p> <p>A: There are 9 one-digit numbers from 1 to 9. There are 90 two-digit numbers from 10 to 99. There are 401 three-digit numbers from 100 to 500. $9 + 90(2) + 401(3) = 1392$. The answer is (b).</p>	<p>CSQA (commonsense)</p> <p>Q: Sammy wanted to go to where the people were. Where might he go?</p> <p>Options: (a) race track (b) populated areas (c) desert (d) apartment (e) roadblock</p> <p>A: The answer must be a place with a lot of people. Race tracks, desert, apartments, and roadblocks don't have a lot of people, but populated areas do. So the answer is (b).</p>
<p>StrategyQA</p> <p>Q: Yes or no: Would a pear sink in water?</p> <p>A: The density of a pear is about 0.6 g/cm³, which is less than water. Thus, a pear would float. So the answer is no.</p>	<p>Date Understanding</p> <p>Q: The concert was scheduled to be on 06/01/1943, but was delayed by one day to today. What is the date 10 days ago in MM/DD/YYYY?</p> <p>A: One day after 06/01/1943 is 06/02/1943, so today is 06/02/1943. 10 days before today is 05/23/1943. So the answer is 05/23/1943.</p>	<p>Sports Understanding</p> <p>Q: Is the following sentence plausible? "Joao Moutinho caught the screen pass in the NFC championship."</p> <p>A: Joao Moutinho is a soccer player. The NFC championship is part of American football, not soccer. So the answer is no.</p>
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04. 논문 결과

Arithmetic Reasoning – Settings

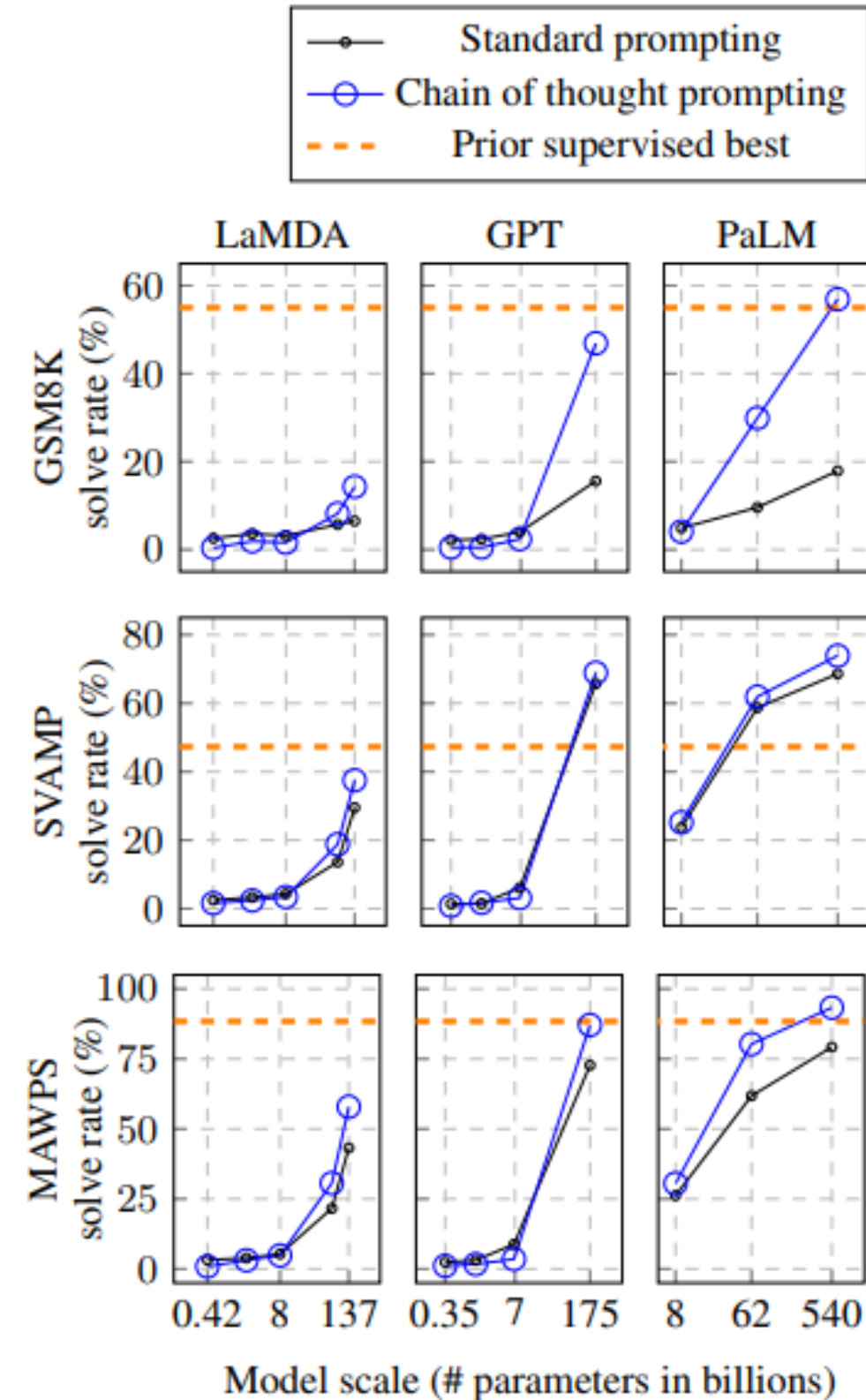
- 해당 방법을 적용할 거대 모델 3가지는 다음과 같음
- GPT-3 (350M,1.3B,6.7B,175B)
- LaMDA (422M,2B,8B,68B,137B)
- PaLM (8B,62B,540B)



04. 논문 결과

Arithmetic Reasoning – Result

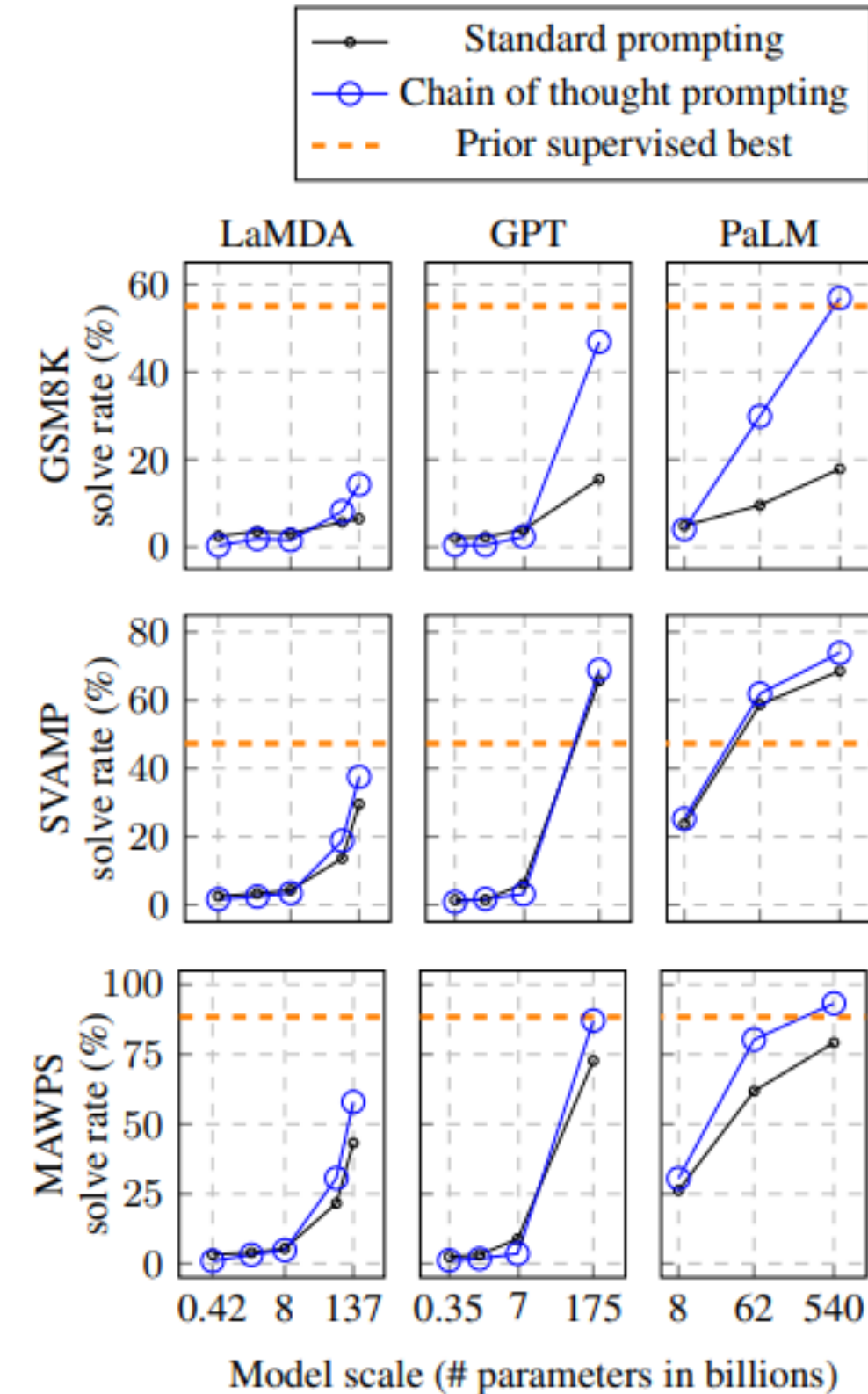
- 작은 모델에서는 오히려 성능 하락 또는 큰 효과가 없는 반면, 파라미터 수가 늘 수록 그 효과가 극명하게 나타남
- Chain of thought의 중간 과정을 검사해본 결과, 작은 모델은 해당 흐름이 비논리적이었으며 그로 인해 성능이 떨어졌음을 알 수 있었음
- 더 복잡한 문제일수록 더 강력한 성능을 보임
- GSM8K의 성적 증가폭이 MAWPS보다 한참 높아짐



04. 논문 결과

Arithmetic Reasoning – Result

- 거대한 모델일 수록 해당 태스크를 위해 Fine tuning 된 모델과 엇비슷한 성능을 내었으며,
• GSM8K에서는 더 높은 성능을 보임
- 이유를 알기 위해 Chain of thought 출력을 직접 확인 -> 최종 답안이 맞았던 모든 출력의 Chain of Thought 또한 논리적
- 최종 답안이 맞지 않았던 경우에도 상당히 근접한 논리적 흐름을 만들어냄



04. 논문 결과

Arithmetic Reasoning – Ablation Studies

- **Equation Only** : 정답을 내기 위해 필요하다고 생각된 수식만을 생성하도록.
- **Variable Compute Only** : 정답을 내는데 필요한 과정에 쓰이는 변수의 수가 중요한가?
- **Reasoning after answer** : 정답을 도출한 후 이유를 생성하도록.
- 모든 추측에서 **Baseline**과 큰 차이가 없었다.

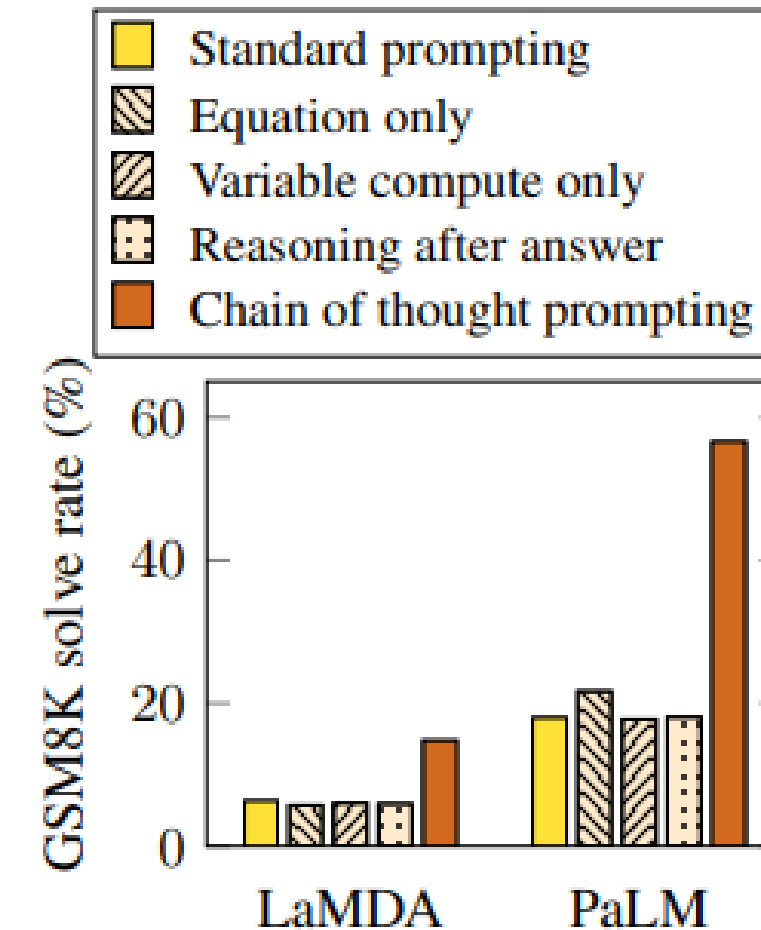
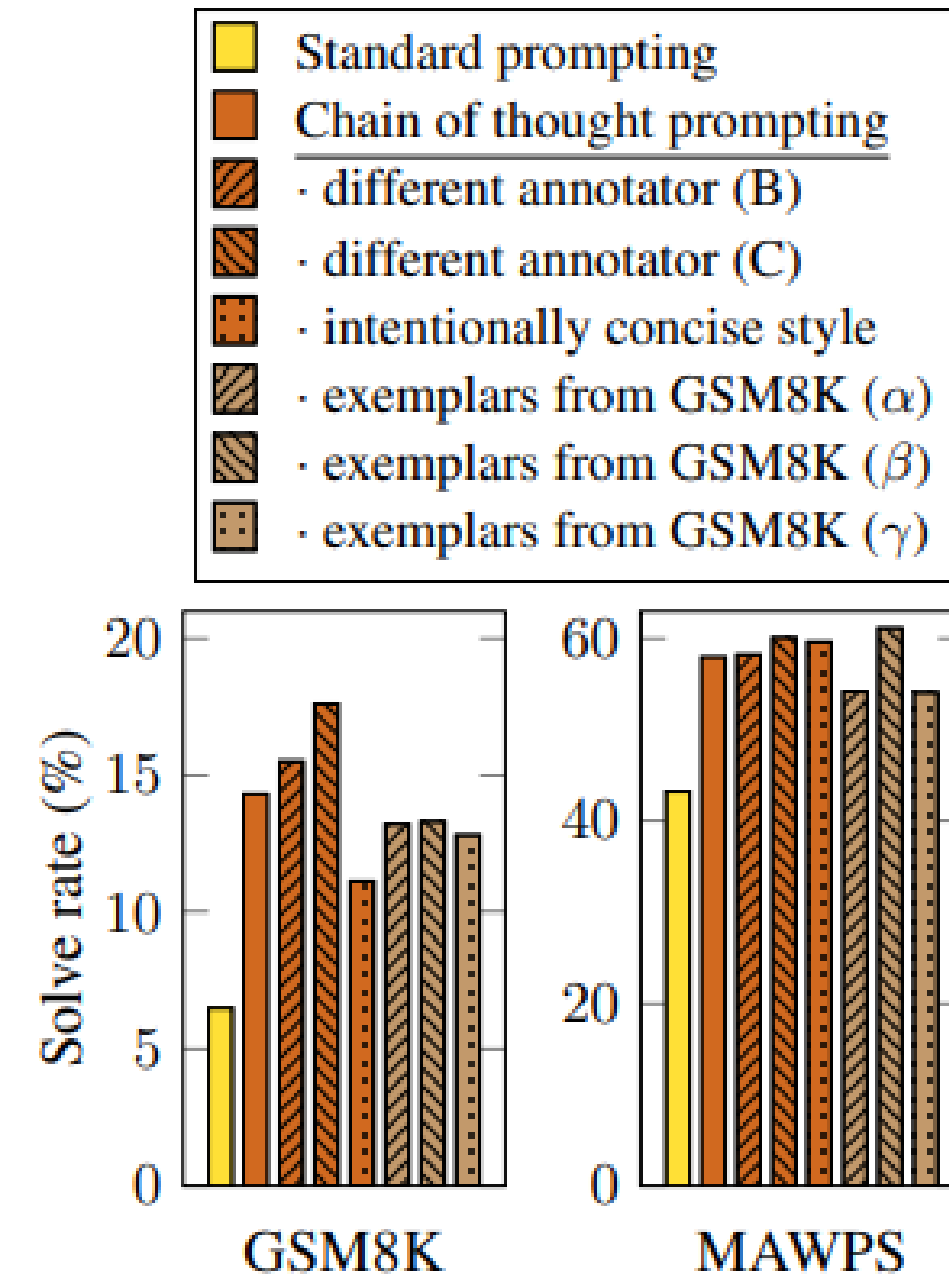


Figure 5: Ablation study for different variations of prompting using LaMDA 137B and PaLM 540B. Results for other datasets are given in Appendix Table 6 and Table 7.

04. 논문 결과

Arithmetic Reasoning – Robustness

- 다른 문체로, 다른 언어로.
- 간결화한 문장 구조로.
- 다른 순서의 예시로.
- 여러 상황에서 공통적으로 기존의 Standard prompting을 높이 상회하는 성능을 보였다.



04. 논문 결과

Commonsense Reasoning

- 상식 문제에서도 상당한 두각을 나타낸다.
- CSQA : 배경지식이 필요한 상식QA
- StrategyQA : 2개 이상의 지식이 필요한 multi-hop QA
- Date Understanding : 날짜에 관한 이해를 필요로 하는 QA
- Sports Understanding : 특정 스포츠에 관련된 문장의 진위여부 판별
- SayCan : 주어진 지시에 맞는 동작 선택 문제

CommonsenseQA	StrategyQA	Date Understanding	Sports Understanding
<p>Q: Sammy wanted to go to where the people were. Where might he go? Options: (a) race track (b) populated areas (c) desert (d) apartment (e) roadblock</p> <p>A: The answer must be a place with a lot of people. Race tracks, desert, apartments, and roadblocks don't have a lot of people, but populated areas do. So the answer is (b).</p>	<p>Q: Yes or no: Would a pear sink in water?</p> <p>A: The density of a pear is about 0.6 g/cm³, which is less than water. Thus, a pear would float. So the answer is no.</p>	<p>Q: The concert was scheduled to be on 06/01/1943, but was delayed by one day to today. What is the date 10 days ago in MM/DD/YYYY?</p> <p>A: One day after 06/01/1943 is 06/02/1943, so today is 06/02/1943. 10 days before today is 05/23/1943. So the answer is 05/23/1943.</p>	<p>Q: Is the following sentence plausible? "Joao Moutinho caught the screen pass in the NFC championship."</p> <p>A: Joao Moutinho is a soccer player. The NFC championship is part of American football, not soccer. So the answer is no.</p>

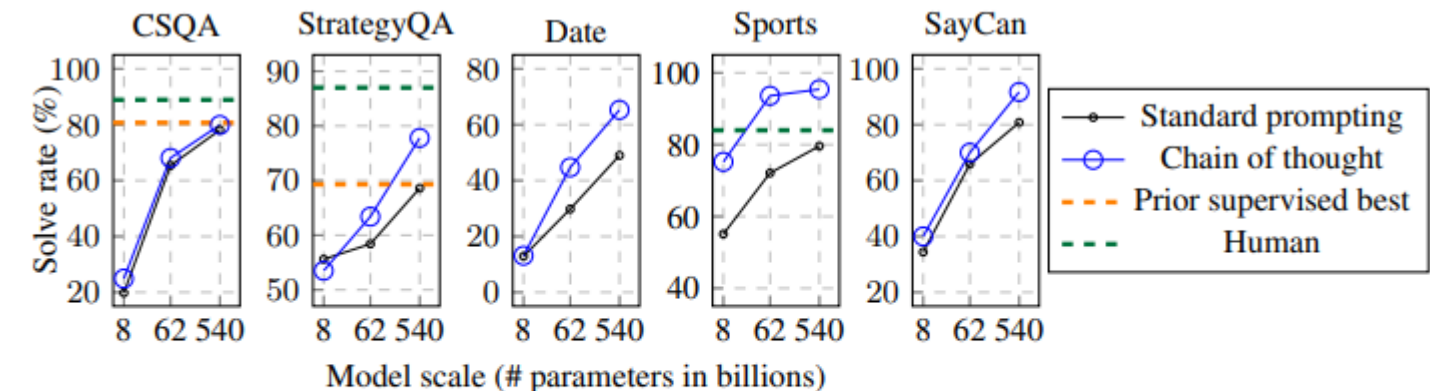


Figure 7: Chain of thought prompting also improves the commonsense reasoning abilities of language models. The language model shown here is PaLM. Prior best numbers are from the leaderboards of CSQA (Talmor et al., 2019) and StrategyQA (Geva et al., 2021) (single-model only, as of May 5, 2022). Additional results using various sizes of LaMDA, GPT-3, and PaLM are shown in Table 4.

04. 논문 결과

Symbolic Reasoning - Tasks

Tasks

- Last letter concatenation
- Coin flip

Table 13: Examples of correct and incorrect chains of thought produced by LaMDA 137B on the letter concatenation task.

QUESTION: Take the last letters of the words in “Waldo Schmidt” and concatenate them.

MODEL ANSWER (CORRECT): The last letter of “Waldo” is “o”. The last letter of “Schmidt” is “t”. Concatenating them is “ot”. So the answer is ot. ✓

QUESTION: Take the last letters of the words in “Daniel Friedman” and concatenate them.

MODEL ANSWER (INCORRECT): The last letter of “Daniel” is “l”. The last letter of “Friedman” is “m”. Concatenating them is “lm”. So the answer is lm. ✗

Table 14: Examples of correct and incorrect chains of thought produced by LaMDA 137B on the coinflip task.

QUESTION: A coin is heads up. Andree flips the coin. Audrie does not flip the coin. Is the coin still heads up?

MODEL ANSWER (CORRECT): The coin was flipped by Andree. So the coin was flipped 1 time, which is an odd number. The coin started heads up, so after an odd number of flips, it will be tails up. So the answer is no. ✓

QUESTION: A coin is heads up. Kristian does not flip the coin. Dallas does not flip the coin. Is the coin still heads up?

MODEL ANSWER (INCORRECT): The coin was flipped by Kristian. So the coin was flipped 1 time, which is an odd number. The coin started heads up, so after an odd number of flips, it will be tails up. So the answer is no. ✗

04. 논문 결과

Symbolic Reasoning - Out of Domain

Out of Domain

Evaluation set에는 몇단계의 추론이 더 존재

Last letter concatenation: 두개의 단어 -> 세개, 네개의 단어

Coin flip: 두 번의 flip -> 네 번, 다섯 번의 flip

04. 논문 결과

Symbolic Reasoning - Result

- Chain of thought 를 사용했을때 toy task 에 대해서 잘 해결함
- 모델 parameter가 100B를 넘지 않으면 여전히 실패
- OOD의 경우 standard prompting은 두가지 task에 대해 모두 실패
- Chain of thought은 모델의 parameter가 커짐에 따라 안정적으로 accuracy 증가

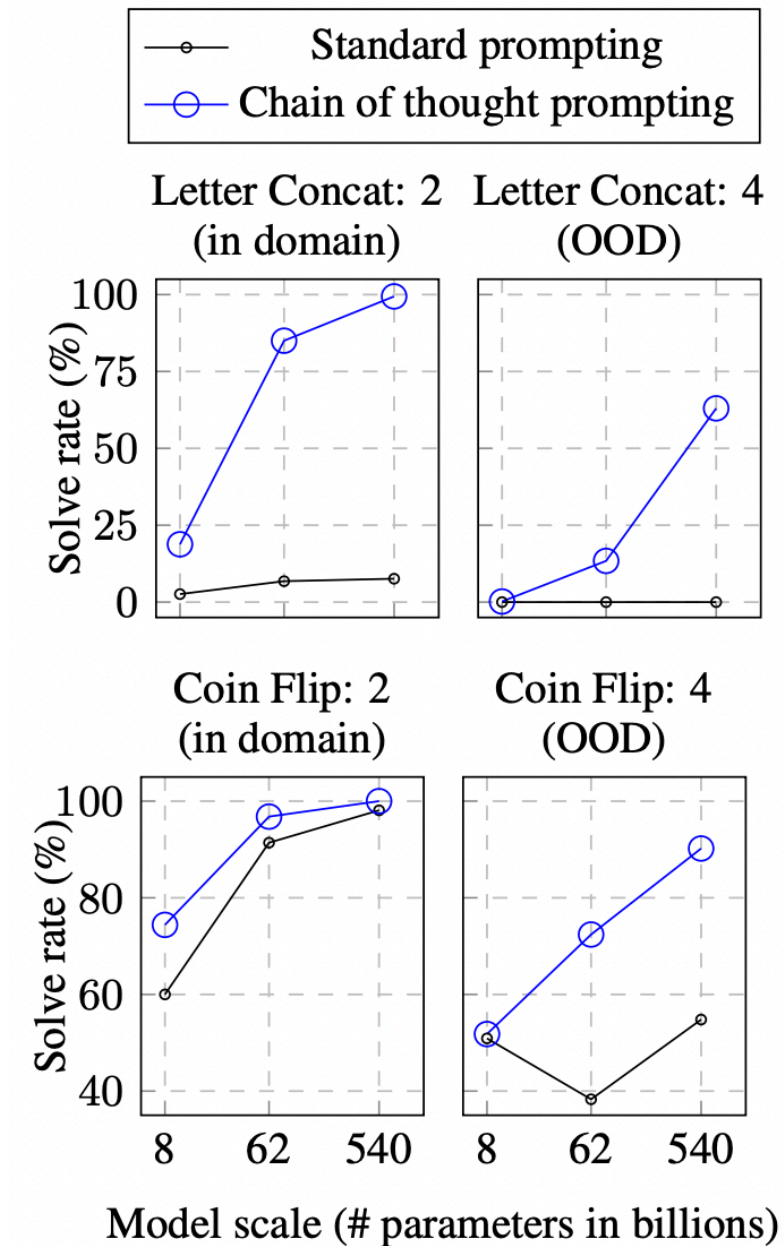


Figure 8: Chain of thought prompting facilitates generalization to longer sequences in two symbolic reasoning tasks.

05. 논리

Arithmetic reasoning

- Chain of thought prompting은 산술추론에서 큰 성능향상을 보임

QUESTION: Mike plays ping pong for 40 minutes. In the first 20 minutes, he scores 4 points. In the second 20 minutes, he scores 25% more points. How many total points did he score?

EQUATION ONLY (WRONG ANSWER): $(4 + 20 * 0.25) = 6$. The answer is 6.

CHAIN OF THOUGHT (CORRECT): Mike played ping pong for 40 minutes. In the first 20 minutes, he scored 4 points. In the second 20 minutes, he scored 25% more points. So he scored 25% more in the second 20 minutes. $4 \times 1.25 = 5$. So he scored 5 points in the second 20 minutes. So he scored 9 points in total. The answer is 9.

05. 논리

Commonsense reasoning

- Commonsense reasoning은 연쇄추론에서 어떻게 적용되는지를 보임

PROMPT FOR CSQA

Q: What do people use to absorb extra ink from a fountain pen? Answer Choices: (a) shirt pocket (b) calligrapher's hand (c) inkwell (d) desk drawer (e) blotter

A: The answer must be an item that can absorb ink. Of the above choices, only blotters are used to absorb ink. So the answer is (e).

Q: What home entertainment equipment requires cable?

Answer Choices: (a) radio shack (b) substation (c) television (d) cabinet

A: The answer must require cable. Of the above choices, only television requires cable. So the answer is (c).

Q: The fox walked from the city into the forest, what was it looking for? Answer Choices: (a) pretty flowers (b) hen house (c) natural habitat (d) storybook

A: The answer must be something in the forest. Of the above choices, only natural habitat is in the forest. So the answer is (b).

05. 논리

Symbolic reasoning

- 사고의 연결이 긴 실험을 통해 OOD에서도 잘 적용되는 것을 보임

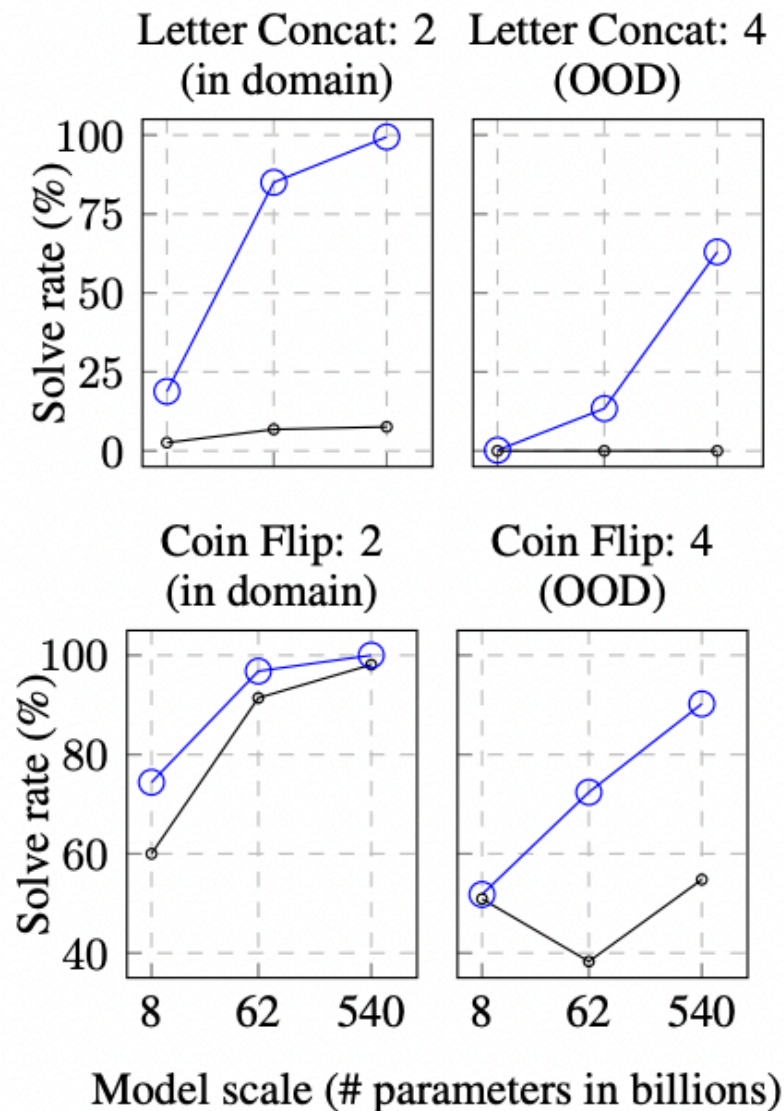


Table 13: Examples of correct and incorrect chains of thought produced by LaMDA 137B on the letter concatenation task.

QUESTION: Take the last letters of the words in “Waldo Schmidt” and concatenate them.

MODEL ANSWER (CORRECT): The last letter of “Waldo” is “o”. The last letter of “Schmidt” is “t”. Concatenating them is “ot”. So the answer is ot. ✓

QUESTION: Take the last letters of the words in “Daniel Friedman” and concatenate them.

MODEL ANSWER (INCORRECT): The last letter of “Daniel” is “l”. The last letter of “Friedman” is “m”. Concatenating them is “lm”. So the answer is lm. ✗

Table 14: Examples of correct and incorrect chains of thought produced by LaMDA 137B on the coinflip task.

QUESTION: A coin is heads up. Andree flips the coin. Audrie does not flip the coin. Is the coin still heads up?

MODEL ANSWER (CORRECT): The coin was flipped by Andree. So the coin was flipped 1 time, which is an odd number. The coin started heads up, so after an odd number of flips, it will be tails up. So the answer is no. ✓

QUESTION: A coin is heads up. Kristian does not flip the coin. Dallas does not flip the coin. Is the coin still heads up?

MODEL ANSWER (INCORRECT): The coin was flipped by Kristian. So the coin was flipped 1 time, which is an odd number. The coin started heads up, so after an odd number of flips, it will be tails up. So the answer is no. ✗

05. 논의

Advantage

- Standard prompting에 비해 scaling curve가 매우 가파름
- Chain of thought prompting은 다양한 large scale model에서 사용가능

Table 2: Standard prompting versus chain of thought prompting on five arithmetic reasoning benchmarks. Note that chain of thought prompting is an emergent ability of model scale—it does not positively impact performance until used with a model of sufficient scale.

Model	GSM8K		SVAMP		ASDiv		AQuA		MAWPS		
	standard	chain	standard	chain	standard	chain	standard	chain	standard	chain	
LaMDA	420M	2.6	0.4	2.5	1.6	3.2	0.8	23.5	8.3	3.2	0.9
	2B	3.6	1.9	3.3	2.4	4.1	3.8	22.9	17.7	3.9	3.1
	8B	3.2	1.6	4.3	3.4	5.9	5.0	22.8	18.6	5.3	4.8
	68B	5.7	8.2	13.6	18.8	21.8	23.1	22.3	20.2	21.6	30.6
	137B	6.5	14.3	29.5	37.5	40.1	46.6	25.5	20.6	43.2	57.9
GPT	350M	2.2	0.5	1.4	0.8	2.1	0.8	18.1	8.7	2.4	1.1
	1.3B	2.4	0.5	1.5	1.7	2.6	1.4	12.6	4.3	3.1	1.7
	6.7B	4.0	2.4	6.1	3.1	8.6	3.6	15.4	13.4	8.8	3.5
	175B	15.6	46.9	65.7	68.9	70.3	71.3	24.8	35.8	72.7	87.1
PaLM	8B	4.9	4.1	15.1	16.8	23.7	25.2	19.3	21.7	26.2	30.5
	62B	9.6	29.9	48.2	46.7	58.7	61.9	25.6	22.4	61.8	80.3
	540B	17.9	56.9	69.4	79.0	72.1	73.9	25.2	35.8	79.2	93.3

05. 논의

Limitation

- Chain of thought가 인간의 사고 과정을 모방하지만, 실제로 network가 이러한 방식으로 추론하는지는 알 수 없다
- Chain of thought 와 large model이 둘 다 필요하다
- Fine tuning 을 위한 annotating 비용이 많이 든다
- Large model에서만 적용가능하여 real-world application에서의 적용이 힘들다

05. 논외 Limitation

<p>Question</p> <p>Tracy used a piece of wire 4 feet long to support tomato plants in the garden. The wire was cut into pieces 6 inches long. How many pieces did she obtain?</p>	<p>62B Model Output</p> <p>She cut the wire into 6 inch pieces. This means she got $4 * 6 = 24$ pieces. The answer is 24. (Incorrect: semantic understanding error)</p>	<p>540B Model Output</p> <p>The wire was 4 feet long. This means it was $4 * 12 = 48$ inches long. It was cut into pieces 6 inches long. This means she obtained $48 / 6 = 8$ pieces. The answer is 8. (Correct)</p>
<p>Question</p> <p>Tom's ship can travel at 10 miles per hour. He is sailing from 1 to 4 PM. He then travels back at a rate of 6 mph. How long does it take him to get back?</p>	<p>62B Model Output</p> <p>He travels from 1 to 4 PM. That means he travels for 3 hours. He travels back at 6 mph. That means he travels for $3 * 6 = 18$ miles. The answer is 18. (Incorrect: semantic understanding error)</p>	<p>540B Model Output</p> <p>He travels at 10 mph from 1 to 4 PM. This means he travels 3 hours. 3 hours at 10 mph means he travels $3 * 10 = 30$ miles. He then travels back at 6 mph. This means he travels 6 miles per hour. He has to travel 30 miles, so it takes him $30 / 6 = 5$ hours. The answer is 5. (Correct)</p>
<p>Question</p> <p>Stephen placed an online order for groceries. His final bill came to \$40.00. Because this was through a delivery vendor, they tacked on a 25% fee to his final total and charged him \$3.00 in delivery fees. Stephen also added a \$4.00 tip. After the extra fees, what was the final price of Stephen's groceries?</p>	<p>62B Model Output</p> <p>The final price of Stephen's groceries was \$40.00. The delivery vendor added 25% to the final total, so the final total was 125% of \$40.00. This means the final total was $125% * \\$40.00 = \\50.00. The delivery vendor also charged \$3.00 in delivery fees. So the final price of Stephen's groceries was $\\$50.00 + \\$3.00 = \\$53.00$. The answer is \$53.00. (Incorrect: one step missing error)</p>	<p>540B Model Output</p> <p>Stephen's bill was \$40.00. The delivery vendor added 25% to the bill. This means the bill was increased by 25% of \$40.00. This is $0.25 * \\$40.00 = \\10.00. The delivery fee was \$3.00. The tip was \$4.00. So the total bill was $\\$40.00 + \\$10.00 + \\$3.00 + 540b \text{ model } \\$4.00 = \\$57.00$. The answer is 57. (Correct)</p>
<p>Question</p> <p>There are four schools competing at a basketball tournament. Each school has sent a girls' basketball team and a boys' basketball team and each team has 5 players each. Each school has also sent a coach for each team. In total, how many people have all of the schools sent?</p>	<p>62B Model Output</p> <p>There are 4 schools. Each school has sent a girls' basketball team and a boys' basketball team. Each team has 5 players each. That means there are $4 * 2 * 5 = 40$ players. Each team has a coach. That means there are $40 + 4 = 44$ coaches. The answer is 44. (Incorrect: one step missing error)</p>	<p>540B Model Output</p> <p>Each school has sent 2 teams, each with 5 players. This means each school has sent $2 * 5 = 10$ players. Each school has also sent 2 coaches. This means each school has sent $10 + 2 = 12$ people. There are 4 schools, so in total all of the schools have sent $4 * 12 = 48$ people. The answer is 48. (Correct)</p>

Figure 10: Examples of semantic understanding and one-step missing errors that were fixed by scaling PaLM from 62B to 540B.

06. 결론

Conclusion of Chain of thought prompting

- Chain of thought prompting은 language model reasoning에 간단하고 범용적으로 적용할 수 있다.
- Large language model에서 더 가파른 성능향상을 보인다
- Language model이 더 많은 task를 해결한다면, language-based reasoning이 더욱 발전할 것이다.

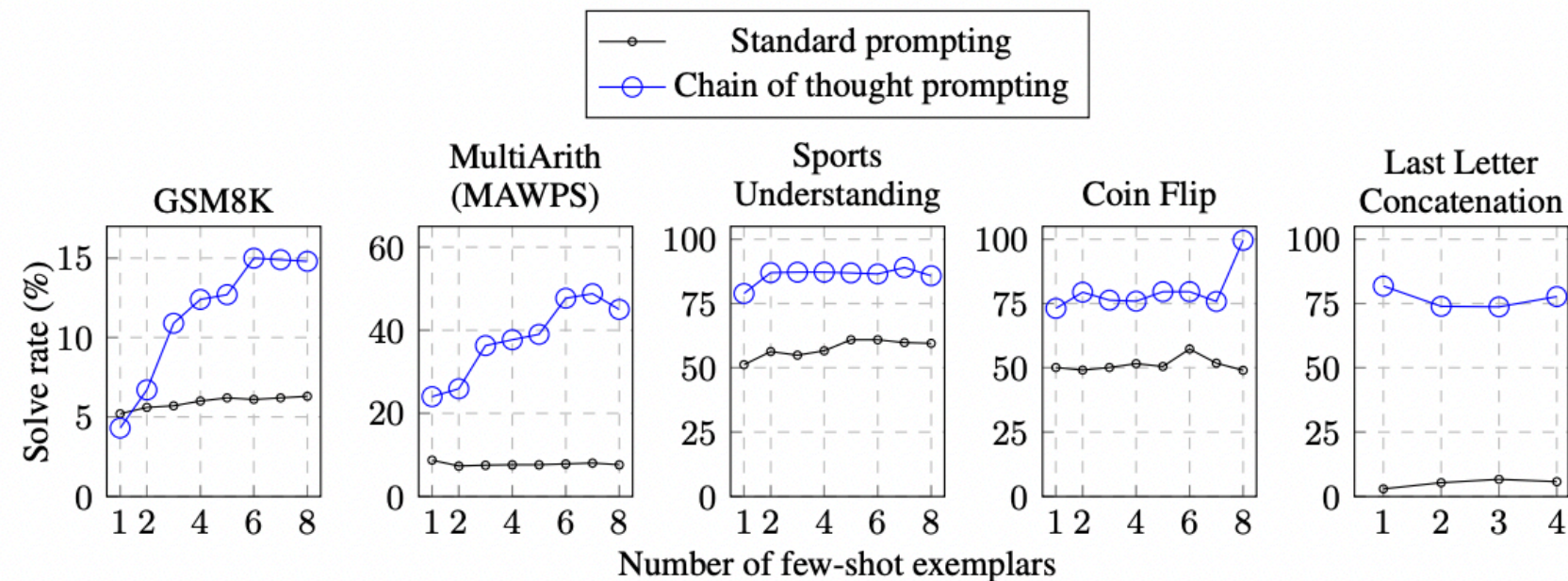


Figure 11: The improvement of chain of thought prompting over standard prompting appears robust to varying the number of few-shot exemplars in the prompt.

감사합니다

2022. 08. 07
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김진환, 김보성, 김수연