

Efficient Tool Use with Chainof-Abstraction Reasoning



14.5

7.8

Gold Reasoning Step

□ CoA

■ CoT Finetuning

14.4

11.5

7.2

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Model with CoA

has more robust

capability in **long**

chain of reasoning,

which benefits from

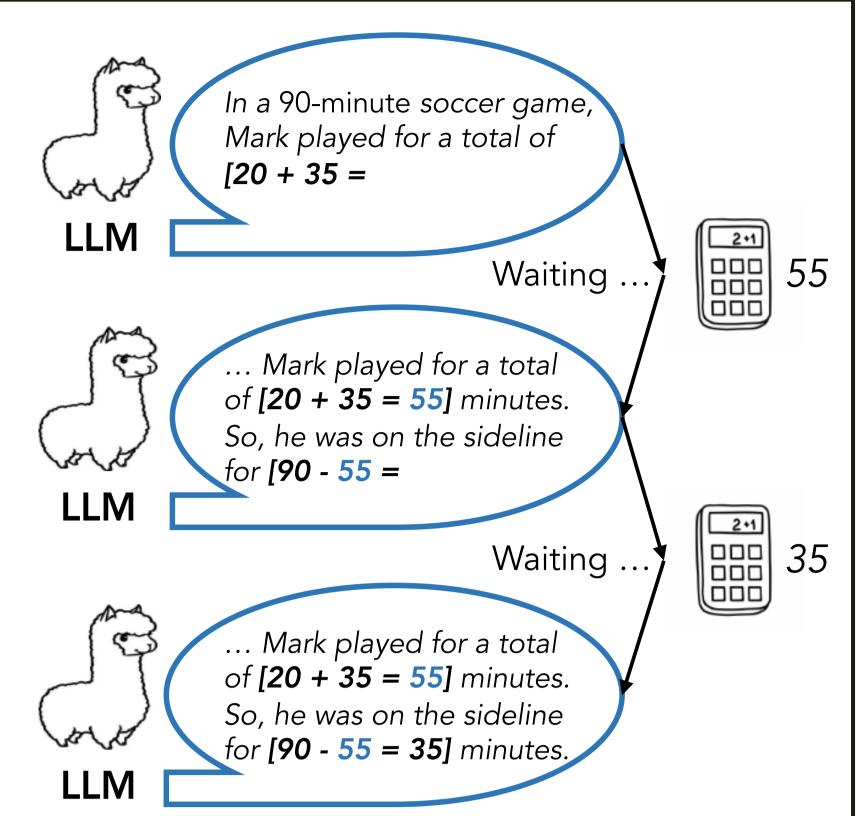
planning abstract

placeholders.

LLM agents use tools to mitigate errors in **multi-step** reasoning, however:

- lack of coordination among multiple tool calls
- need to wait for tool responses

How to achieve better efficiency and holistic planning of tool use?

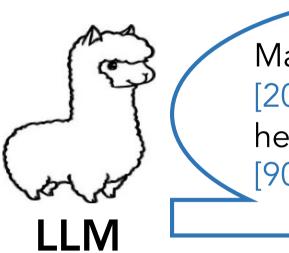


Chain-of-Abstraction (CoA) Reasoning

In a 90-minute game, Mark played 20 minutes, then another 35 minutes.

minutes, then another 35 minutes.

How long was he on the sideline?

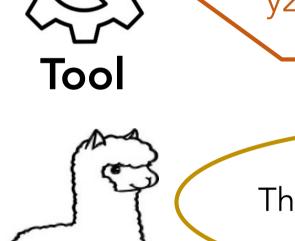


Mark played for a total of [20 + 35 = y1] minutes. So, he was on the sideline for [90 - y1 = y2] minutes.



LLM

y1 = 20 + 35 = 55y2 = 90 - y1 = 90 - 55 = 35



The answer is 35 minutes.

LLMs plan reasoning chains with abstract placeholders:

- inter-connect multiple tool calls
- robust to variation of knowledge
- more feasible and general strategies

Wikipedia-based QA

Ralph Hefferline was a psychology professor at a university. In which city is this university located?

Search the [university of Ralph Hefferline - WikiSearch-> y1], which is [y1 -NER-> y2]. Then find the [city y2 is in -WikiSearch-> y3].

- y1: Ralph Hefferline was a professor at Columbia University ...
- y2: Columbia University
 y3: Columbia University is an Ivy League
 university in New York ...
 - The answer is New York.

Domain tools infill knowledge once to the whole CoA:

- CoA decoding for next question can start while tools infill current CoA
- more **efficient** multiple inferences

CoA Finetuning Data Construction

Tool

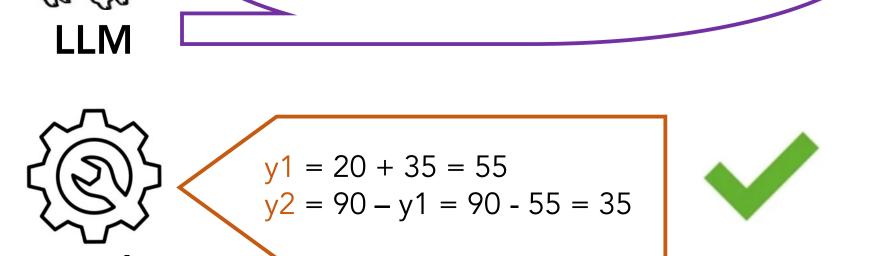
Simple method to build finetuning data for LLM agents to learn CoA:

- prompt LLMs to **re-write** existing gold answers to abstract chains
- domain tools **verify** the correctness of answer re-writing

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[90 - y1 = y2] minutes.

CoA improves Accuracy of reasoning **Mathematical Reasoning** Wikipedia-based QA 5.53 8-shot CoT **Prompting** -2 LLaMa-2-Chat-7B LLaMa-2-Chat-70B LLaMa-2-Chat-7B LLaMa-2-Chat-70B ■ Chain-of-Thought (CoT) Finetuning ■ Toolformer (Schick et al., 2023) ■ Toolformer-Math/Wiki □ CoA (ours) - finetuned on original CCNet - finetuned on our in-domain data created by Schick et al. math or Wiki QA data CoA outperforms CoT and Toolformer on both in-distribution and OOD test sets, average ~6% absolute accuracy improvement over 8-shot CoT prompting. Mathematical Reasoning on GSM8K Why? **16.3**

12.6 12.9

10

Accuracy

over

8-shot CoT

Prompting

CoA improves reasoning Efficiency Method CoA decoding **Toolformer CoT Prompting (8-shot)** does **not** need **CoA Finetuning (Ours) CoT Finetuning** to **wait** for (seeded with LLaMa-2-Chat-7B) external tool responses. **0** 3.5 Performance benefits do not come with increased computational costs. >5 **Gold Reasoning Step**

