LLMSteer: Improving Long-Context LLM Inference by Steering Attention on Reused Contexts

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NEURAL INFORMATION PROCESSING SYSTEMS

Introduction and Background

Large Language Models (LLMs) excel at tasks like question answering, summarization, and reasoning but require augmentation for domain-specific or user-specific knowledge.

- **Challenge:** Incorporating supplemental contexts (thousands of tokens) is challenging due to the *lost-in-the-middle problem* and high runtime costs.
- **Prefix Caching:** Systems reuse Key-Value (KV) caches for frequently used contexts to avoid repeated prefill processing, improving efficiency.
- **Persistent Limitations:** Despite prefix caching, models often lose track of critical information because KV pairs remain static.
- **We tackle just one question**: Can we achieve both high efficiency and high quality *without* fine-tuning models?

Previous Work

- **Attention Steering:** PASTA [1] and AutoPASTA [2] reweight highlighted input tokens. AutoPASTA automates this via iterative prompting.
- **Limitations:** AutoPASTA increases runtime (2 LLM calls) and breaks prefix caching, making KV caches non-reusable.

Our Approach

Insights

- Single-pass processing may overlook important tokens in the context.
- Multi-pass prompting with varied prefixes identifies tokens needing more attention through consistently high attention scores.

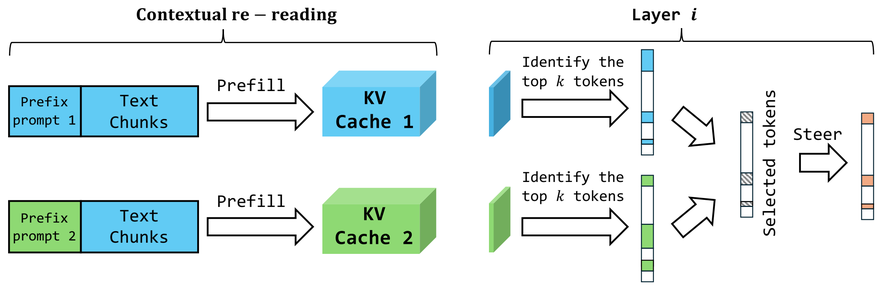


Figure 1: LLMSTEER processes the same context twice with different prefix prompts, generates KV caches, and reweights selected tokens.

Design: LLMSTEER consists of THREE steps

- **Contextual re-reading:** Process the context twice with different prefix prompts.
- **Token Selection:** Compute cumulative attention scores, select top-k tokens.
- **Steering**: Scale up the attention weight of selected tokens.

Example

GSM8K

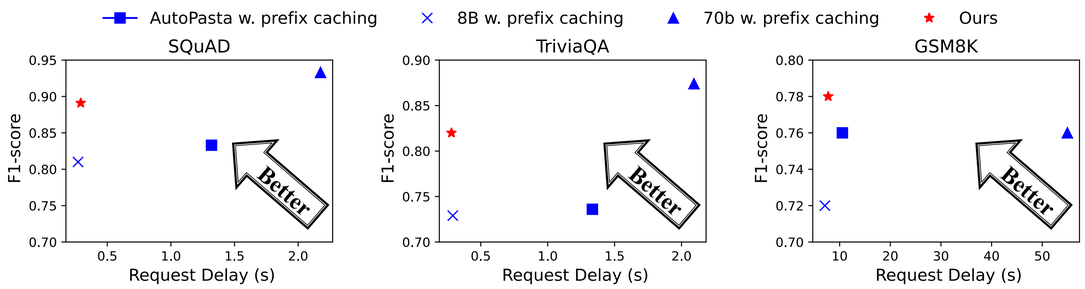
Q: A bag of chips has 250 calories per serving. If a 300g bag has 5 servings, how many grams can you eat if your daily calorie target is 2000 and you've already consumed 1800 calories?
A: 48g

W. Prefix Prompt 1:
"... Since there are 5 servings in the bag, the number of grams that can be eaten is 0.8 x 300g = 240g ..."
(*Incorrect: Miscalculated by using the total bag weight instead of grams per serving.*)

W. Prefix Prompt 2:
"... 0.8 servings is approximately equal to 1 serving. The bag has 5 servings, and it weighs 300g. So, each serving weighs: 300g ÷ 5 servings = 60g. Therefore, you can eat approximately: 60g"
(*Incorrect: Rounded 0.8 servings up to 1 serving, ignoring the fraction of grams.*)

Steered:
"Since the bag is 300g and there are 5 servings, each serving is 300 / 5 = 60g. Therefore, the number of grams that can be eaten is 0.8 x 60 = 48g."
(*Correct: Combines Prefix 1's fraction handling and Prefix 2's grams-per-serving calculation, producing the correct process and answer.*)

Evaluations



References

[1] Qingru Zhang, Chandan Singh, Liyuan Liu, Xiaodong Liu, Bin Yu, Jianfeng Gao, and Tuo Zhao. Tell your model where to attend: Post-hoc attention steering for llms, 2023.
[2] Anonymous. Model tells itself where to attend: Faithfulness meets automatic attention steering. In *Submitted to ACL Rolling Review - June 2024*, 2024.

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