Stress-Testing Long-Context Language Models with Lifelong ICL and Task Haystack



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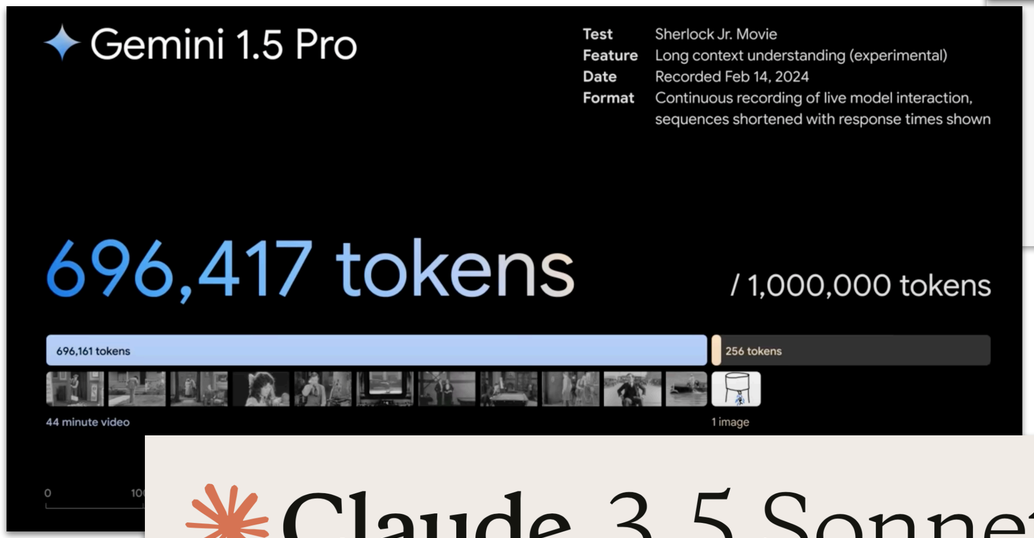
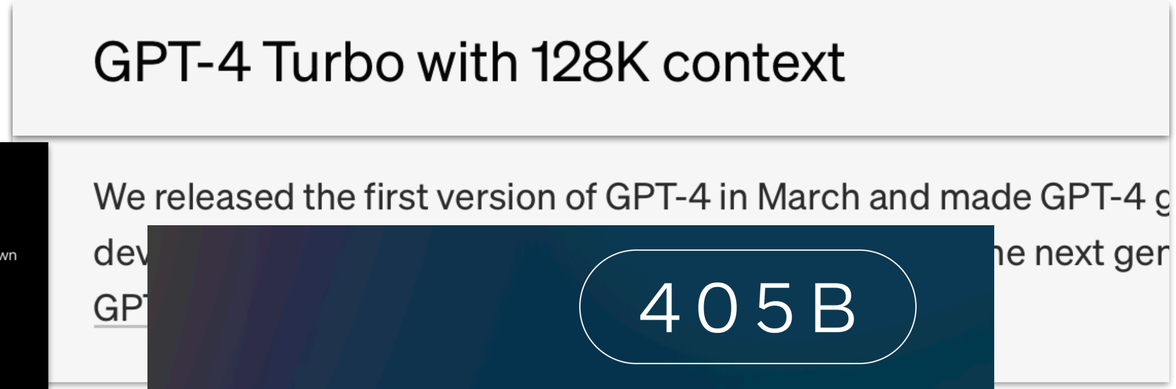
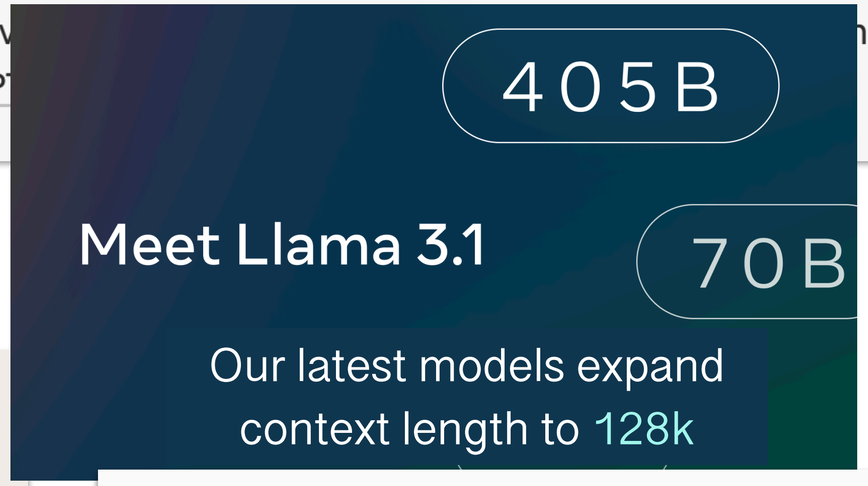
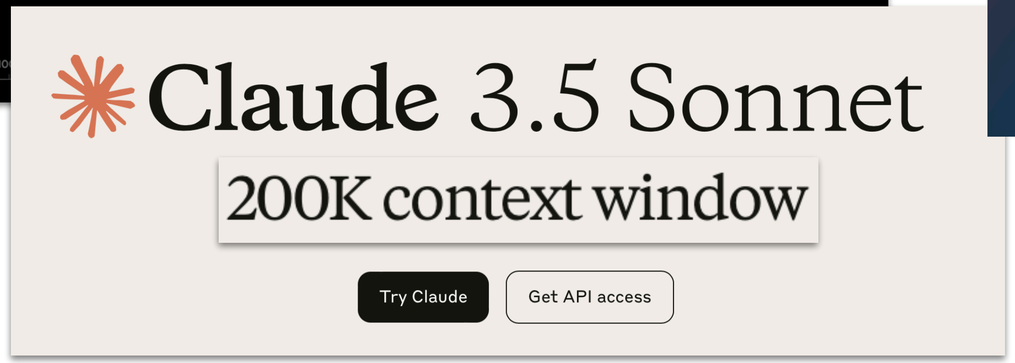
Background

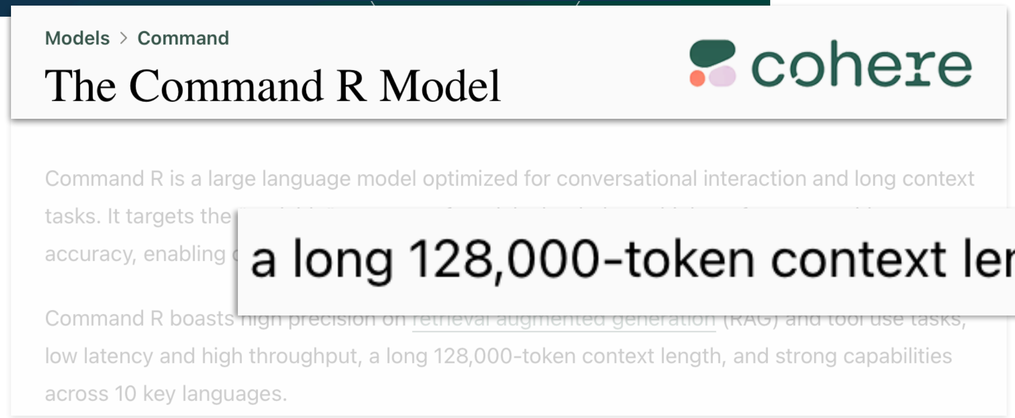
Longer context windows in LMs!











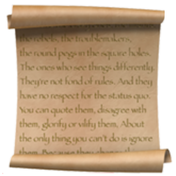
Background

How to evaluate long-context models?

Realistic Benchmarks

✔ reflect real-world performance

✗ time-consuming, hard to scale



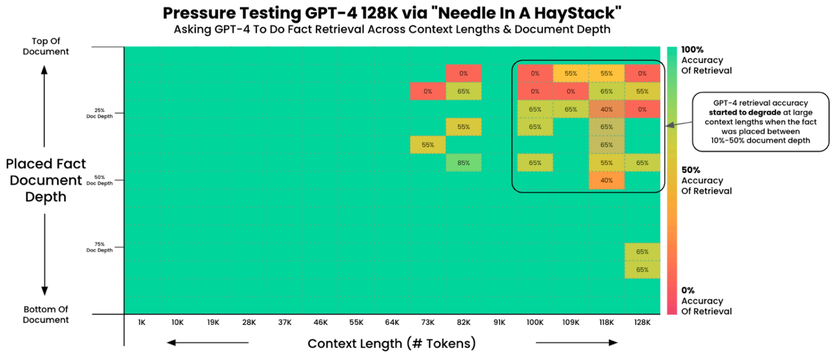
SCROLLS: Standardized CompaRison Over Long Language Sequences

Shaham et al., 2022

Synthetic Benchmarks

✔ easy to control and scale

✗ limited to copying-and-pasting capabilities



https://github.com/gkamradt/LLMTest_NeedleInAHaystack

A new approach: Lifelong ICL and Task Haystack

Single-task ICL & Task Haystack

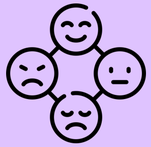
Classify if the text is humorous. // Instruction
Text: …
Label: humorous
Text: …
Label: not humorous // Demonstrations
Text: <new text>
Label: ?

Lifelong ICL & Task Haystack

Determine if the sms message is ham or spam.
Message: …
Label: ham.
Message: …
Label: spam

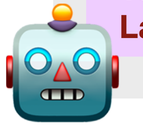
Classify if the text is humorous. **// Instruction**
Text: …
Label: humorous
Text: …
Label: not humorous **// Demonstrations**

Categorize a tweet into six basic emotions: …
Tweet: …
Emotion: fear
Tweet: …
Emotion: anger

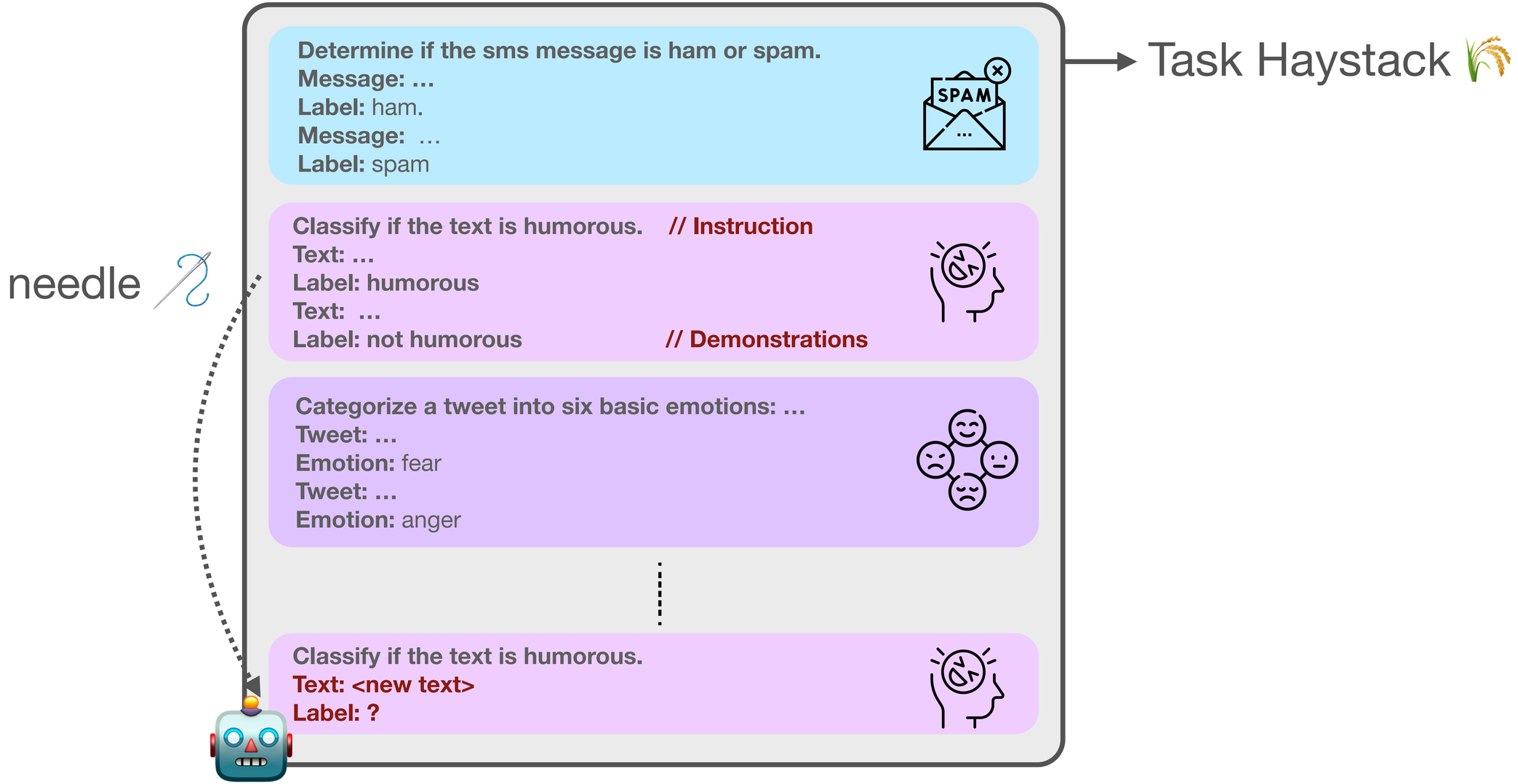


⋮

Classify if the text is humorous.
Text: <new text>
Label: ?



Lifelong ICL & Task Haystack



Lifelong ICL & Task Haystack

✔ **Controllable**

More tasks, more shots
→ longer context

Determine if the sms message is ham or spam.
Message: …
Label: ham.
Message: …
Label: spam

Classify if the text is humorous. **// Instruction**
Text: …
Label: humorous
Text: …
Label: not humorous **// Demonstrations**

Categorize a tweet into six basic emotions: …
Tweet: …
Emotion: fear
Tweet: …
Emotion: anger

⋮

Classify if the text is humorous.
Text: <new text>
Label: ?

✔ **More than copying-and-pasting**

ICL requires deeper, contextual understanding

✔ **With realistic elements**

Based on realistic text classification tasks

Defining "Pass Rate" in Task Haystack

Single-task ICL

Classify if the text is humorous. // Instruction
Text: ...
Label: humorous
Text: ...
Label: not humorous // Demonstrations
Text: <new text>
Label: ?

Lifelong ICL

Determine if the sms message is ham or spam.
Message: ...
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Message: ...
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Classify if the text is humorous. // Instruction
Text: ...
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Text: ...
Label: not humorous // Demonstrations

Categorize a tweet into six basic emotions: ...
Tweet: ...
Emotion: fear
Tweet: ...
Emotion: anger

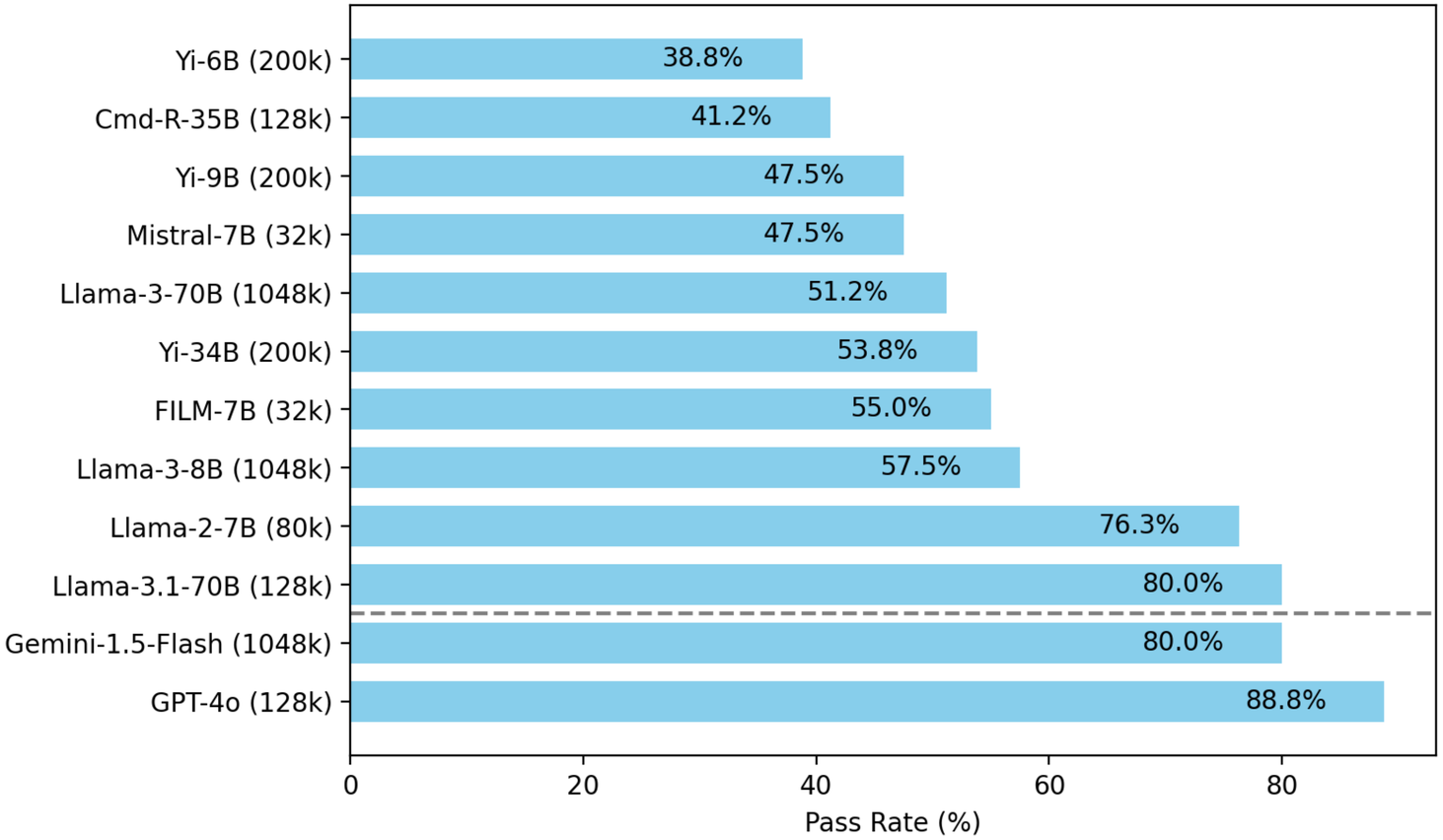
⋮

Classify if the text is humorous.
Text: <new text>
Label: ?

Model "***passes***" when performance of **Lifelong ICL** is *not significantly worse* than **Single-task ICL**

Benchmarking Long-context Language Models

In our 16-task 8-shot setting (context size=32k)



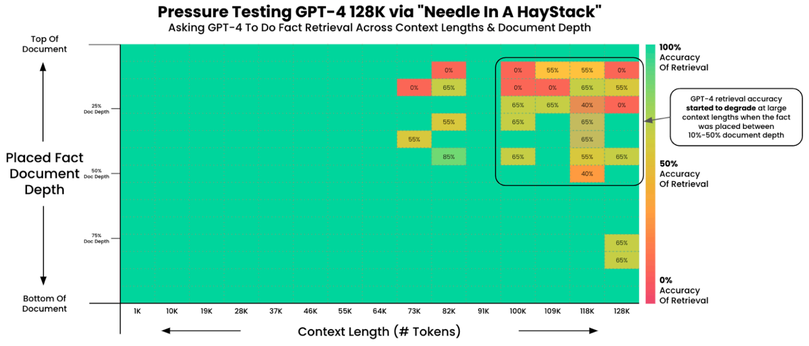
Most long-context models struggle. Failing up to 60% cases.

GPT-4o is the strongest model. Still fails ~11% of the cases

Llama-3.1-70b is the strongest open-weight model.

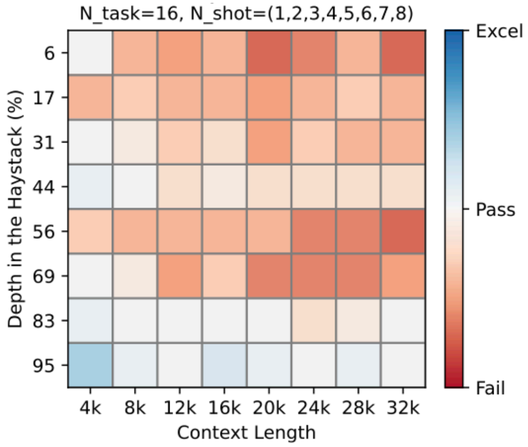
Needle-in-a-haystack Style Visualization

Needle-in-a-haystack

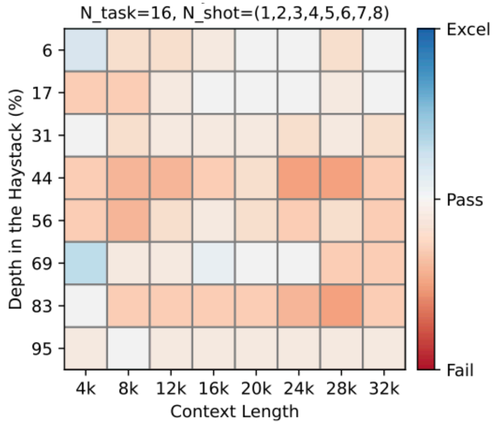


https://github.com/gkamradt/LLMTest_NeedleInAHaystack

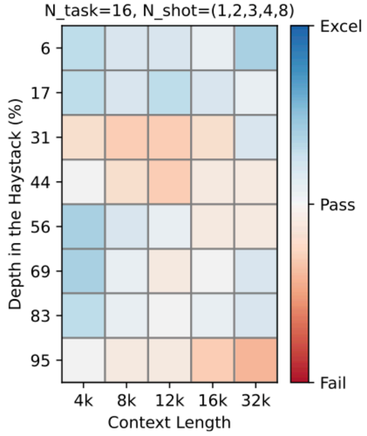
Needle-in-a-**Task**-haystack



Mistral-7B (32k)



Llama-3.1-70B (128k)



GPT-4o (128k)

Controlled Experiments

Setting	Input Prompt Example	Controlled Factors: Long Ctx.	Distraction	Recency
Baseline (Single-task ICL)	T1 Train **T1 Test**	✗	✗	✓
Random	Random Text T1 Train **T1 Test**	✓	✓	✓
Repeat	T1 Train T1 Train T1 Train **T1 Test**	✓	✗	✓
Repeat+Shuffle	T1 Train ⤮ T1 Train ⤮ T1 Train **T1 Test**	✓	✗	✓
Recall (Lifelong ICL)	T1 Train T2 Train T3 Train **T1 Test**	✓	✓	✗
Replay	T1 Train T2 Train T3 Train T1 Train **T1 Test**	✓	✓	✓
Remove	T2 Train T3 Train **T1 Test**	✓	✓	N/A
Paraphrase	T1 Train T2 Train T3 Train ↻ **T1 Test**	✓	✓	✗

Distraction

Recency bias

Instruction understanding

- Recency bias and distraction both contribute the the failures in Task Haystack
- Models are sensitive to paraphrased instructions, indicating a lack of deeper understanding.

Summary

We introduce **Lifelong ICL** to evaluate long-context LMs, which challenges them to learn a sequence of language tasks through in-context learning

We develop **Task Haystack**, which comprises 64 classification tasks, to assess and diagnose how long-context LMs utilize contexts in Lifelong ICL

We benchmark 14 models and find that

(1) SOTA model (GPT-4o) **fails ~11%** cases
(2) Llama-3.1-70b shows the best performance among open-weight models
(3) Other open-weight models lag behind by a large margin
(4) Long-context models are sensitive to recency bias, distraction and paraphrased instructions