

Why

Reasoning based on clear, rule-based information (e.g. math)

Reasoning based on fuzzy and imprecise information (e.g. Natural language based)

- Relying on NL that do not capture information with precise granularity (Novak, 2015).
- An under-explored field for complex, real-world reasoning.

Whether LLMs handle fuzzy reasoning in the same way as precise (math) reasoning?

Where

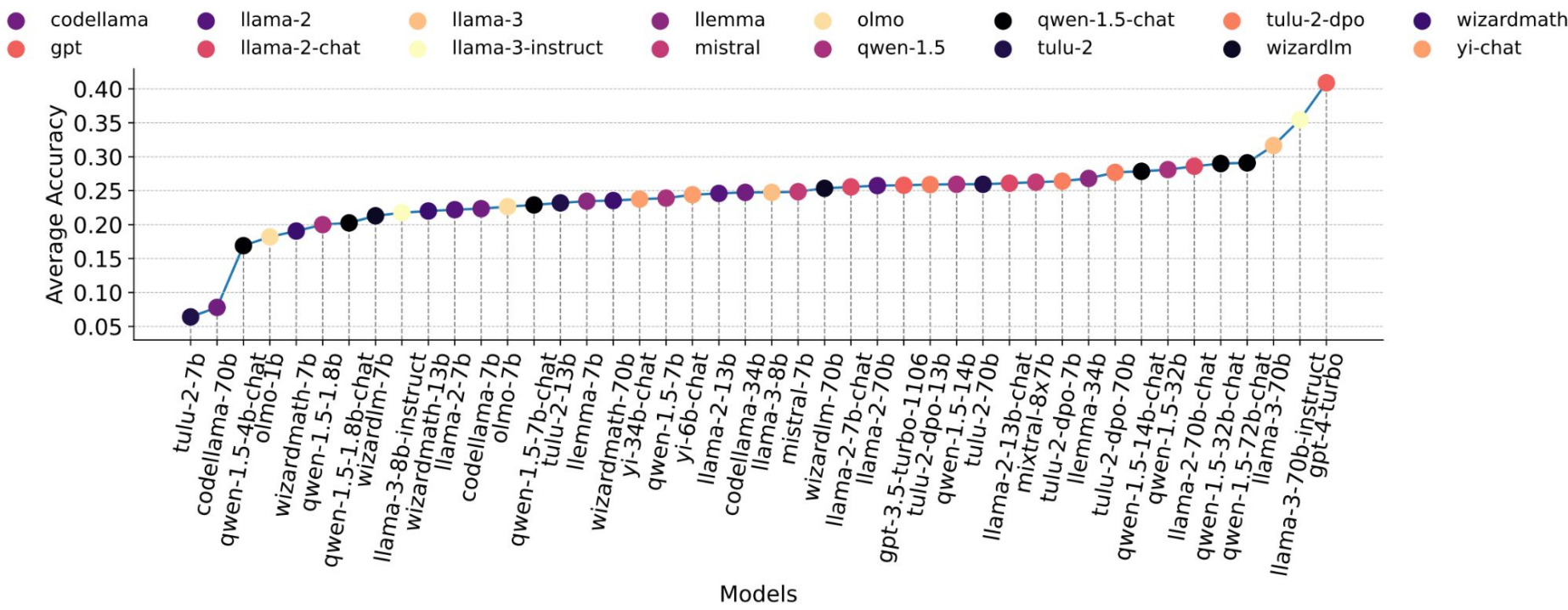
Do LLMs handle fuzzy reasoning as strong as math reasoning?

FRoG: Evaluating Fuzzy Reasoning of Generalized Quantifiers in Large Language Models

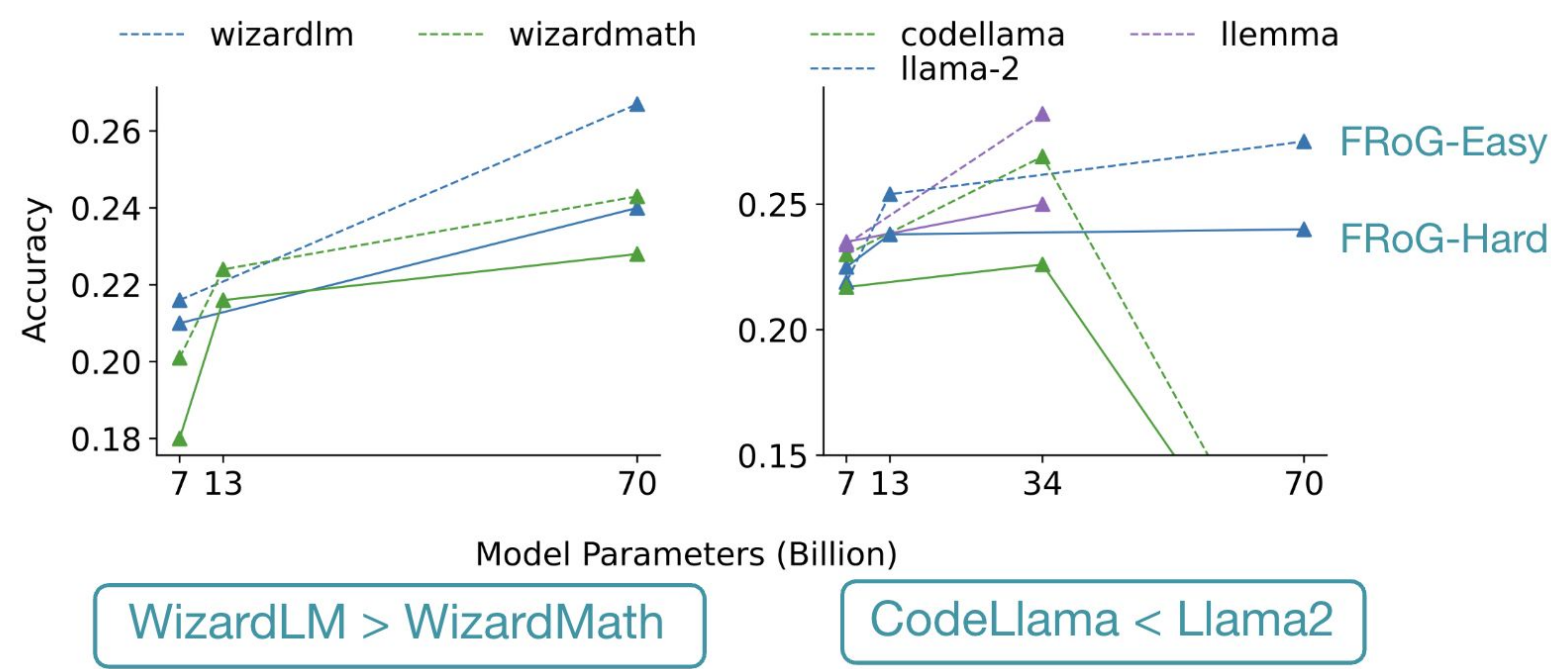
Yiyuan Li, Shichao Sun, Pengfei Liu

How to Have Strong Fuzzy Reasoning?

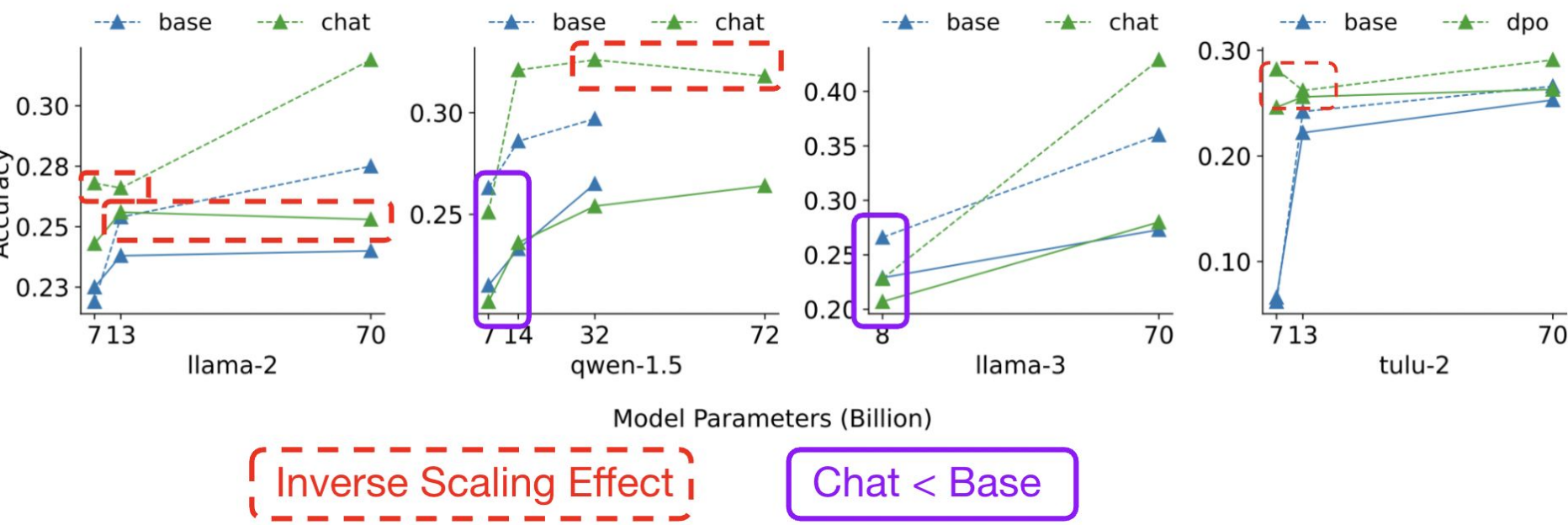
5-shot, CoT



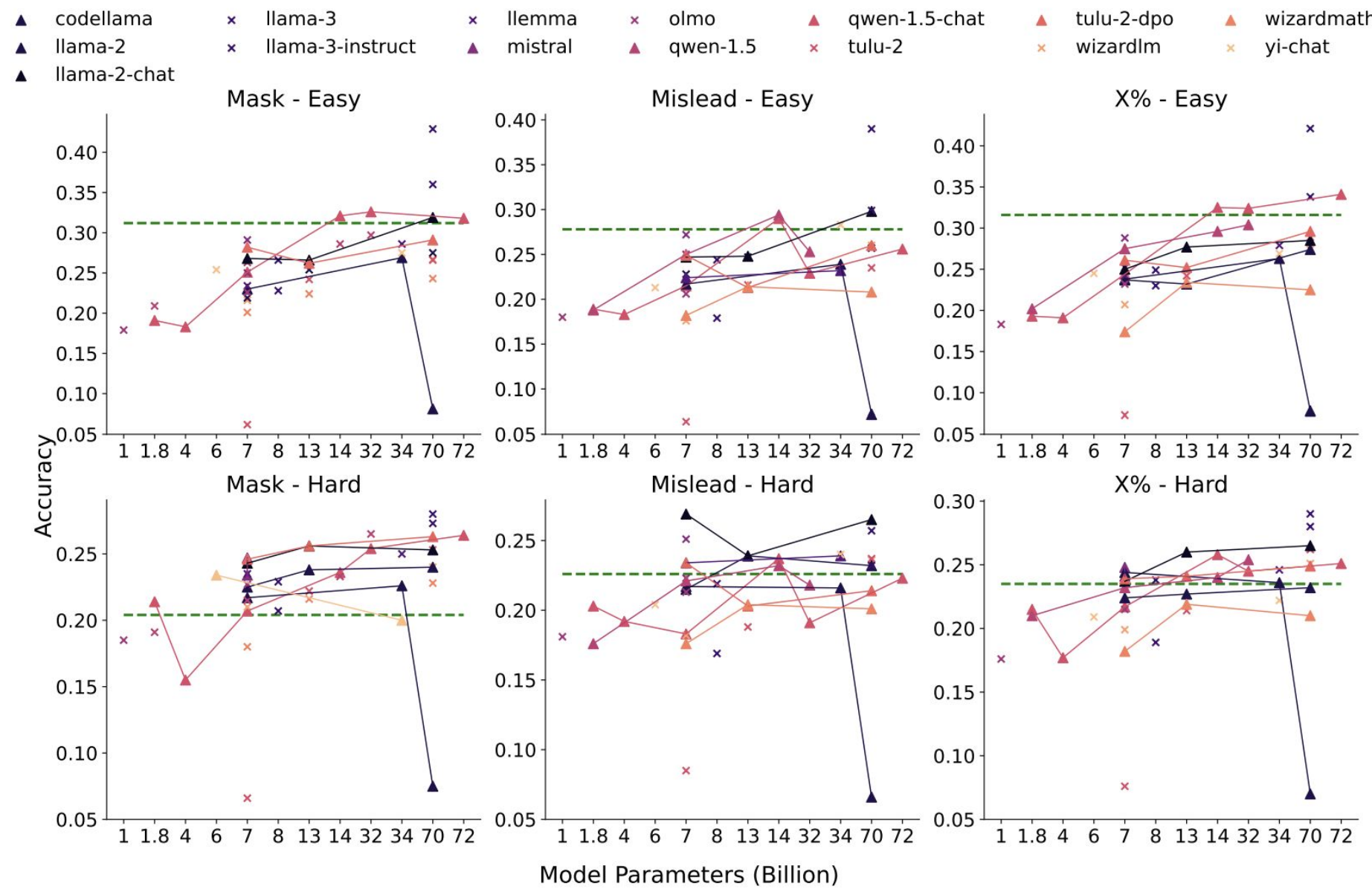
I. Math/Code Tuning - No



II. General Alignment - Maybe



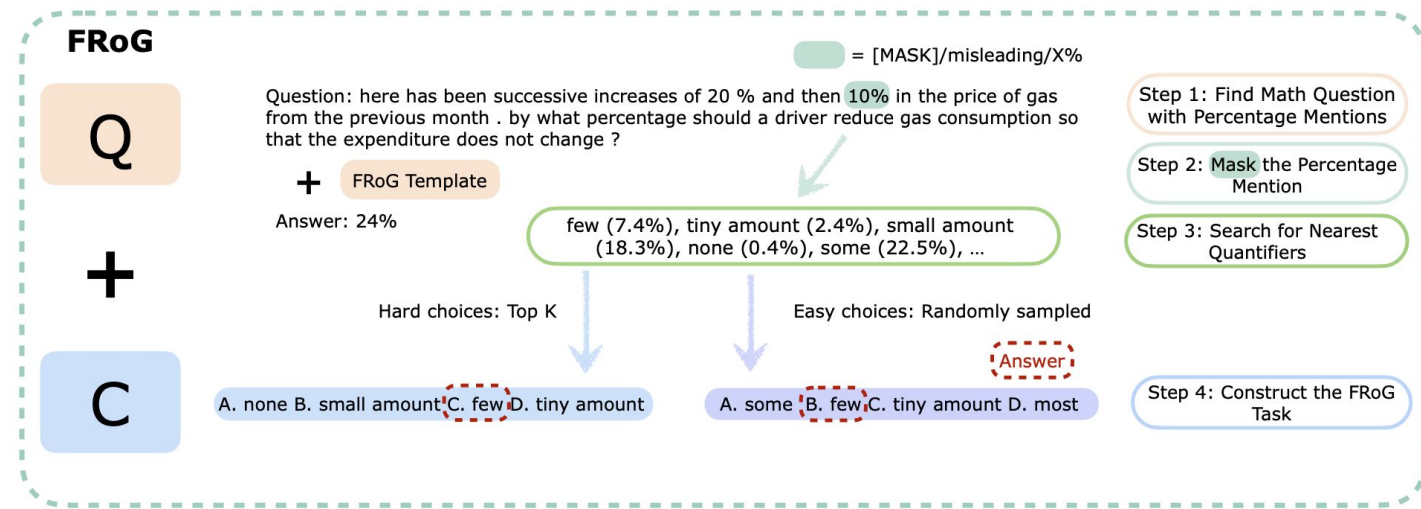
III. Larger Model - 50% Times lines for inverse scaling



How

Generalized Quantifier (GQs) expressions articulated fuzzy event + Math problems (2k GSM8K + MathQA).

There have been successive increases of 20% and then most in the price of gas from the previous month. By what percentage should a driver reduce gas consumption so that the expenditure does not change?



TL; DR

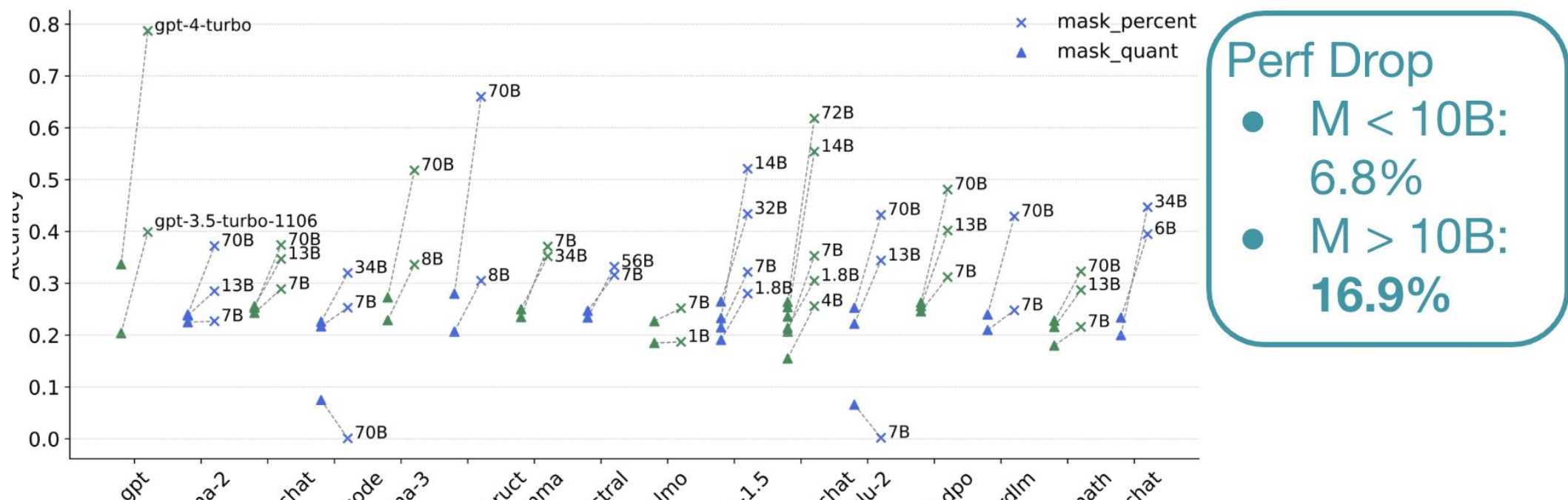
- A benchmark for fuzzy reasoning based on real-world complex math reasoning problems.
- Models w/ stronger math reasoning can perform worse.
- Quantifier estimation is model-sepecific.

IV. Generalization from Strong Math Reasoning - No

Fuzzy vs Precise Reasoning

Q: Here has been successive increase of 20% and then [MASK] in the price of gas from the previous month. By what percentage ....

- mask\_quant fuzzy
  - A. none B. small amount C. few D. tiny amount
- mask\_percent precise
  - A. 0.4% B. 18.3% C. 10% D 2.4%



Reasoning Patterns

Phase I: Locating the target percentage value

- Directly solving the target percentage value (standard)
- Approaching a close-enough percentage value.
- Incomplete solution (e.g. unsolved euqations)

Phase II: Quantifier estimation

Explicit

Implicit

Ex1: Kelly has had 3 pay cuts in her salary in the past 6 months. If the first pay cut was 8%, the second pay cut was 14%, and the third was [MASK]. What will be the percentage decrease, if the salary is decreased in a single shot? If the answer to the question is 35.12%, then please select the quantifier that is closest to the meaning of [MASK] from the following choices. [18%]  
A. few B. some C. tiny amount D. small amount  
Suppose that Kelly's initial salary is 100 units for simplicity. After the first pay cut of 8%, her salary becomes 92 units. The second pay cut of 14% reduces her salary further to 92 \* (1 - 0.14) = 79.12 units. Let the third pay cut be x%. We need to find x such that the overall reduction is equivalent to a single reduction of 35.12%. This means the final salary should be 100 \* (1 - 0.3512) = 64.88 units. Setting up the equation: 79.12 \* (1 - x/100) = 64.88. Solving for x: (1 - x/100) = 64.88 / 79.12 ≈ 0.8202, hence x/100 = 1 - 0.8202 = 0.1798 or x = 17.98%.  
Knowing the value of x, we can compare it to the options given:  
- A few (typically refers to a small number, but greater than 'tiny amount')  
- Some (could imply a moderate to considerable amount, usually more ambiguous)  
- Tiny amount (implies very small, likely less than our calculated 17.98%)  
- Small amount (suggests a moderate but not large percentage).  
Between these choices, 'small amount' best describes a reduction of 17.98%, as it's significant but not very large or tiny. Therefore, the best choice is D. small amount.

Ex2: The average price of a decoration piece has increased over the years. If from 1990 to 1996, the price of the decoration piece increased by [MASK] and from 1996 to 2001 it increased by 20%, what is the price of the decoration piece in 2001 if the price in 1990 was \$11500? If the answer to the question is \$15594, then please select the quantifier that is closest to the meaning of [MASK] from the following choices. [13%]  
A. some B. tiny amount C. few D. small amount  
First, we need to calculate the price of the decoration piece in 1996 based on an unknown percentage increase from 1990. Let the percentage increase from 1990 to 1996 be x%. If the price in 1990 was \$11500, then the price in 1996 after x% increase would be \$11500 \* (1 + x/100). From 1996 to 2001, the price increased further by 20%, so the price in 2001 would be: \$11500 \* (1 + x/100) \* 1.2. The final value is given as \$15594. So we have: \$11500 \* (1 + x/100) \* 1.2 = \$15594. Solving for x: (1 + x/100) = \$15594 / (\$11500 \* 1.2); (1 + x/100) = \$15594 / \$13800; (1 + x/100) ≈ 1.13; x/100 = 0.13 x = 13%. So, the price increased by 13% from 1990 to 1996. Given the choices of 'some,' 'tiny amount,' 'few,' and 'small amount,' a 13% increase is not negligible but is not very large either. Among the provided options, 'small amount' seems to be the closest match to a 13% increase. Therefore, the answer is D. small amount.

Other Findings

- Correct percentage value/quantifier estimation ≠ correct GQ.
- Same model family + same percentage value ≠ same GQ.