Improving Language Model Reasoning with Self-motivated Learning

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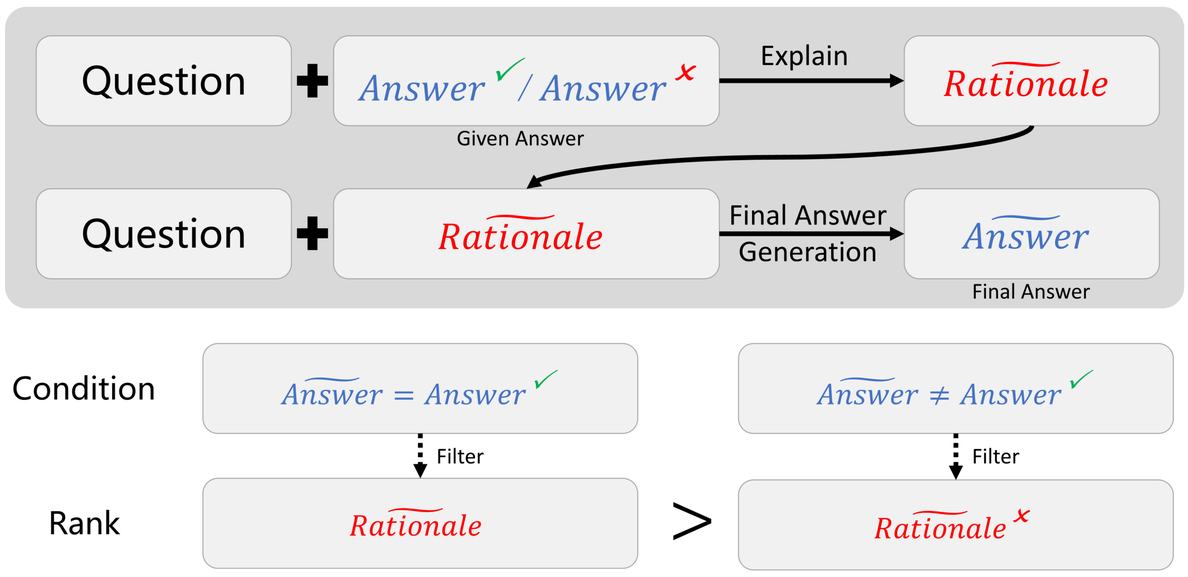
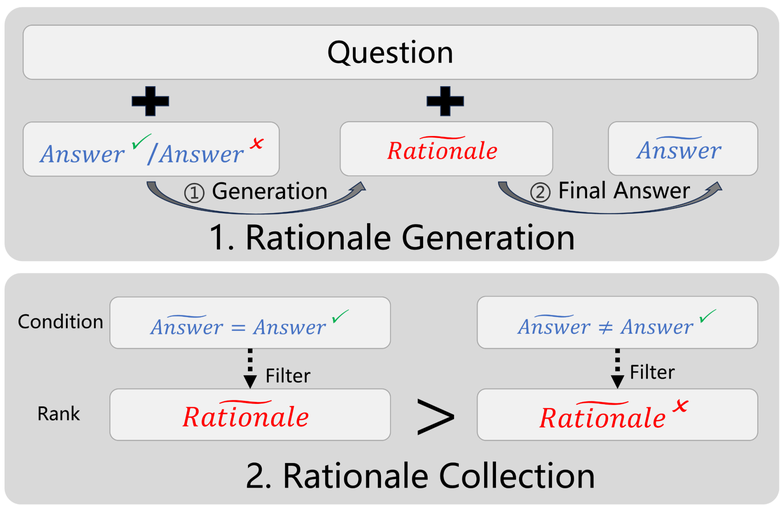
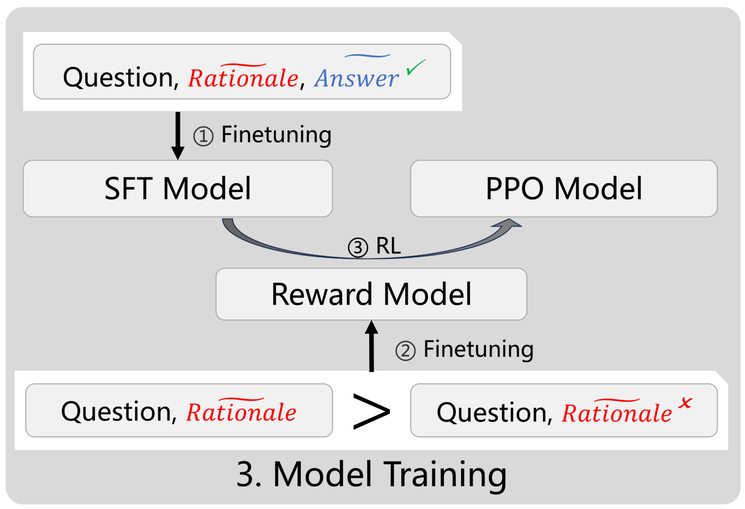
Motivation & Background

- Models gain reasoning capability
  - After trained with data that has rationales
- Lacks of datasets with high-quality rationales
  - high annotation cost
- How to use existing datasets without rationales?
  - Utilize the correctness
  - Correct is better than Wrong



Method





Dataset	Choices	Training Samples	Test Samples	Data Split	License	References
SingleEq	-	356	152	70:30	None	Koncel-Kedziorski et al. (2015a)
AddSub	-	276	119	70:30	Unspecified	Hosseini et al. (2014)
MultiArith	-	420	180	70:30	Unspecified	Roy and Roth (2016)
SVAMP	-	700	300	70:30	MIT	Patel et al. (2021a)
GSM8K	-	7473	1319	Original	MIT	Cobbe et al. (2021)
Date Understanding	5–6	258	111	70:30	Apache-2.0	Srivastava et al. (2022)
CommonSenseQA	5	9741	1221	Original	Unspecified	Talmor et al. (2018)
StrategyQA	2	1603	687	70:30	Apache2.0	Geva et al. (2021a)

Rationale Generation	Final Answer Generation
[Instruction and Question] <q_i> [Answer] <a'> [Rationale] <$\hat{r}_i$>	[Instruction and Question] <q_i> [Rationale] <$\hat{r}_i$> [Answer] <$\hat{a}_i$>

Prompt For Better Rationale	Prompt For Worse Rationale
[Instruction and Question] Would a pear sink in water? [Answer] No [Rationale] *The density of a pear is about 0.6g/cm3, which is less than water. Objects less dense than water float. Thus, a pear would float.*	[Instruction and Question] Would a pear sink in water? [Answer] Yes [Rationale] *The density of a pear is about 0.6g/cm3, which is less than water. Objects less dense than water float. Thus, a pear would sink.*

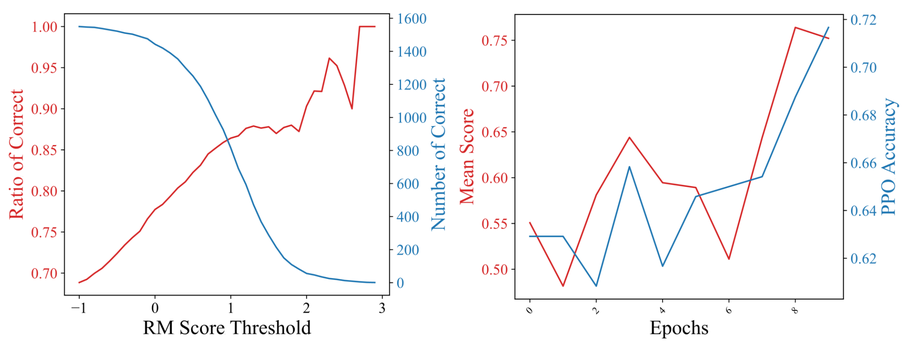
Experiments

Method	Param	Single Eq	Add Sub	Multi Arith	SVAMP	GSM8K	Date Understanding	Common SenseQA	Strategy QA
Close-Source Models									
text-davinci-003	175B	86.4	81.3	83.7	73.6	59.5	77.0	70.0	61.1
text-davinci-002	175B	82.24	78.99	78.89	64.67	40.26	73.87	61.75	53.57
Open-Source Models									
StableVicuna	13B	62.50	57.14	43.33	46.67	40.26	45.95	58.64	41.34
LLama2-Chat	7B	73.03	68.91	67.22	53.67	28.35	35.14	56.67	38.14
Methods on Llama2 7B									
Few-shot-CoT	7B	63.82	54.62	35.00	39.00	14.60	53.15	50.61	61.28
Few-shot-CoT$^{SC=8}$	7B	67.76	67.23	55.56	44.67	15.09	35.13	48.40	62.45
Fine-tune	7B	71.05	63.87	11.67	45.67	12.58	64.87	76.58	65.21
Fine-tune-CoT (text-davinci-002)	7B	70.39	72.27	76.67	47.33	–	73.88	–	58.95
Fine-tune-CoT (STaR)	7B	75.66	67.23	72.78	44.33	17.29	81.98	63.63	64.63
Fine-tune-CoT (Llama2)	7B	71.05	65.55	53.33	40.67	13.72	83.78	69.53	60.84
Self-motivated Learning	7B	**76.32**	**76.47**	**80.00**	**55.33**	**18.88**	**87.39**	**77.97**	**66.08**

- Accuracy (%) in 8 tasks under our different models and methods. Note that the methods based on the LLama2 7B are trained in different datasets separately.
- The Self-motivated Learning applies PPO for reinforcement learning in the training dataset using the Fine-tune-CoT model, resulting in an average increase of 10.68%.

Method	SingleEq	AddSub	MultiArith
Fine-tune-CoT (text-davinci-002)	70.39	72.27	76.67
+RL	71.71	78.16	80.56
Increase	+1.32	+5.89	+3.89

- The reward model trained with rank information exhibits a certain degree of generalization.



- The reward of model can reflect the performance.
- The performance is increasing during training.

Conclusion

• We propose "Self-motivated Learning", a framework is grounded in the idea that a rationale leading to the correct answer is superior to one leading to an incorrect answer.
• We conducted experiments across different datasets encompassing three categories of complex reasoning, demonstrating that our method can significantly enhance model performance without external annotation.

Acknowledgement

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